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Class 7

The IIT Foundation Series

CHEMISTRY

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Preface

As the old adage goes, "nothing succeeds like success." The truth in this maxim cannot be overstated in today's competitive world. The present-day student is under immense pressure to thrive and emerge triumphantly in examinations. Students aspire to get into pre-eminent educational institutes to pursue the best courses–be it in engineering, medicine, arts or sciences–to enable them to prepare for careers at the global level. Their performance in entrance examinations are often the cornerstones that determine if they would be admitted into these hallowed halls of learning. With most of these exams being designed to challenge the innate talent and ingenuity of students, it is only natural that they find these tests most demanding and that they find themselves competing with the country's best minds for those few coveted seats. Only those students with a thorough understanding of the fundamental concepts and exceptional problem-solving skills pass out with flying colours in these tests.

The "IIT Foundation Series" books are designed to provide students with a comprehensive understanding of the fundamental concepts, to teach them the application of these concepts and to hone their problem-solving skills.

The objective of the IIT Foundation Series books is to ensure that students are able to delve beyond the restrictions of their regular school syllabus and get a fundamental understanding of Mathematics, Physics and Chemistry. The books are designed to kindle student interest in these subjects and to encourage them to ask questions that lead to a firm grip on the principles governing each concept.

Irrespective of the field of study that the student may choose to take up later, it is imperative that he or she develops a sound understanding of Mathematics and Science, since it forms the basis for most modern-day activities. Lack of a firm background in these subjects may not only limit the capacity of the student to solve complex problems but also lessen his or her chances to make it into top-notch institutes that provide quality education.

This book is intended to serve as the backbone of the student's preparation for a range of competitive exams, going beyond the realms of the usual school curriculum to provide that extra edge so essential in tackling a typical question paper.

A distinctive feature of this book is that it has been written by a team of well-qualified teachers experienced in imparting the fundamentals of Mathematics and Science, and their applications to active learners at T.I.M.E. (Triumphant Institute of Management Education Pvt. Ltd). They have also been instrumental in developing high-quality study material for IIT Foundation courses for Classes 7 to 10. We are sure that you will find this book, prepared by such stalwarts, to be very useful in your preparation for entrance examinations.

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About the IIT Foundation Series

This book is a perfect companion not only for the students of 7th Grade, but also for higher grades. It will help them achieve the much-needed conceptual clarity in the topics which form the basis for their higher study.

Some of the important features of the book are listed below:

- Builds skills that will help students succeed in school and various competitive examinations.
- The methodology is aimed at helping students thoroughly understand the concepts in Mathematics, Physics and Chemistry.
- Helps develop a logical approach to Mathematics, Physics and Chemistry, thereby enabling more effective learning.
- Lays stress on questions asked by board/school examinations as well as application of concepts.
- The concepts are explained in a well structured and lucid manner, using simple language. This aids learning.
- A large number of examples have been included to help reinforce the concepts involved.
- Different levels of practice exercises have been provided which help students develop the necessary application and problem-solving skills.
- The exercises have been designed keeping in mind the various board/school examinations and competitive examinations, such as the NTSE, NLSTSE, Science Olympiad and Cyber Olympiad.
- The book will not only help the students in better understanding of what is taught in regular school classes (and hence enable them to do well in board examinations) but will also help in developing the acumen, resulting in a distinctive edge over their peers.
- Given below are a few examples that demonstrate how the course will help students in understanding the fundamentals:

How does a kingfisher catch fish?

The kingfisher flies vertically over the position of the fish, then plunges into the water at a 90° angle. The concept here is that the normally incident rays do not undergo refraction, hence the fish lies exactly where it appears to be. At any other angle, the apparent location of the fish would be different from its real location.

Why do we normally swing our arms while walking, and why not when we carry a load in our hands?

The center of gravity of a body depends on the distribution of mass in the body. As we walk, the movement of the legs tends to cause a shift in the centre of gravity. To compensate for this shift we swing our arms. When we are carrying a load in the hands, however, the effective C.G is lower, making it easier to maintain balance.

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Why does salt become damp when kept exposed during the rainy season and not when kept exposed during summer?

In the rainy season humidity in the atmosphere is very high, i.e., there is a lot of moisture in the atmosphere. Thus, calcium chloride, which is the impurity present in common salt, absorbs this moisture and makes the salt damp. In summer, however, as the temperature is high, calcium chloride tends to loose moisture through the process of evaporation, and the salt is left free-flowing.

Structure of the IIT Foundation Series

The IIT Foundation Series is available in Mathematics, Physics and Chemistry. Each chapter in the book is divided into three parts, namely, theory, test your concepts and concept application.

➤ **Theory:**

The theory part deals with the various concepts in Physics/Chemistry/Mathematics, which is a part of the syllabus prescribed by major boards for Class X. The concepts are explained in a lucid manner, and diagrams have been provided, wherever necessary, to illustrate these concepts.

➤ **Test your Concepts:**

This exercise is provided at the end of the theory section of each chapter. These exercises are a collection of very short answer, short answer and essay type of descriptive questions. It is intended to provide students with model questions that they may face in the board examination.

Students are expected to prepare for these questions before they attempt any examination based on that particular chapter. Towards the end of the book, the students will find key points for selected questions of the exercise. These key points provide students with an idea of the points that should be a part of an answer for such a question.

➤ **Concept Application:**

This is a collection of exercises in four different classes: Class 7, Class 8, Class 9 and Class 10.

Class 7 consists of basic objective questions. These questions test the basic knowledge of students and enable them to gauge their understanding of concepts when they start solving this exercise. The key for this exercise is provided at the end of the respective chapter.

Classes 8, 9 and 10 consist of descriptive questions of a higher level of difficulty. These questions help students to *apply the concepts* that they have learnt. Key points for selected questions of these exercises have been provided at the end of each chapter in order to help students solve these questions.

These books are available for 7th, 8th, 9th and 10th classes separately for Mathematics, Physics and Chemistry.

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1

Classification of Matter

INTRODUCTION

The planet earth is endowed with a large variety of substances like rocks, water, air, coal, petroleum etc. The beauty of the earth is attributed to the difference in physical appearance and behaviour of these substances. But all these substances irrespective of their physical appearance and behaviour, have certain things in common that is mass and the space they occupy and are commonly called **matter**. Hence **matter** can be defined as anything that **occupies space** and has **mass**. The basic building block of matter is known as **molecule**. **Molecule** is the smallest constituent particle of matter which retains all the properties of the matter and has independent existence. The arrangement of these molecules gives rise to the variation in the physical appearance and behaviour of matter. Based on the physical appearance and behaviour, matter can be classified into three different states—**solid, liquid and gas**.

Arrangement of molecules in three different states of matter

Molecules are packed in different ways in three different states of matter which leads to the variation in other parameters like intermolecular space, intermolecular force of attraction and the movement of molecules.

Intermolecular space: The space between the constituent molecules of matter is called **intermolecular space.**

Intermolecular forces of attraction: The attractive forces that exist between the adjacent molecules of matter are called **intermolecular forces of attraction.** Intermolecular forces of attraction can be of two types, that is, cohesive forces and adhesive forces depending on the nature of the participant molecules involved.

Cohesive and adhesive forces

The forces of attraction between the molecules of the same substance are known as **cohesive forces** whereas, **adhesive forces** are those which exist between the molecules of two different substances. For example, water molecules stick to the glass rod due to adhesive force.

The comparative study of three different states of matter with respect to the arrangement of molecules and other related parameters is presented below in the tabular form.

Table 1.1

Parameter	Solids	Liquids	Gases
Packing of molecules	Very closely packed	Loosely packed	Very loosely packed
Intermolecular space	Negligible	More than that among the solid molecules	Maximum among the three states of matter
Intermolecular force of attraction	Maximum among the three states of matter	Less than that among the solid molecules	Negligible
Type(s) of movement of molecules	Vibrate to and fro about a fixed position	Vibrate to and fro, rotate around their own axis and move from one place to other within certain limit	Vibrate to and fro, rotate around their own axis and move from one place to other randomly in all directions with much higher speed than the liquid molecules

Due to the above differences, matter around us exhibits differences in the physical properties. The following table represents the comparative study of physical properties of different states of matter.

Table 1.2

Property	Solids	Liquids	Gases
Mass	Definite mass	Definite mass	Definite mass
Volume	Definite volume	Definite volume	No definite volume
Shape	Definite shape	No definite shape, take the shape of the container	No definite shape
Density	High density	Lesser density than solids	Least density
Compressibility	Incompressible	Slightly compressible	Highly compressible
Rigidity	Rigid (cannot flow)	Fluid (can flow)	Fluid (can flow)
Free surfaces	Any number of free surfaces	One free surface that is only the upper surface	No free surfaces
Thermal expansion	Very low	Higher than solids	Much greater than both solids and liquids
Diffusion	Do not diffuse	Some liquids can diffuse spontaneously into another (example: water and alcohol), but others do not diffuse. (example: oil and water)	Gases diffuse spontaneously and rapidly.

Interconversion of states of matter

The existence of matter in a particular state depends on two factors that is temperature and pressure. Matter can be transformed from one state to another by altering the temperature and pressure and this phenomenon is called **interconversion of states of matter**. Different types of interconversion of states of matter are given below:

(i) Melting

The process which involves the change in state of matter from solid to liquid by heating is called **melting or fusion**. The temperature at which a solid changes into a liquid on heating at normal atmospheric pressure is called the **melting point** of that solid.

☛ *Example* Ice changes to water at 0°C under normal atmospheric pressure. Hence 0°C is called melting point of ice.

(ii) Boiling

The process which involves the change in state of matter from liquid to gas from the bulk of liquid by heating is called **boiling.** The temperature at which a liquid changes into gas from the bulk of the liquid by heating at normal atmospheric pressure is called the **boiling point** of that liquid.

☛ *Example* Water changes to water vapour at 100°C under normal atmospheric pressure. Hence 100°C is called boiling point of water.

Every liquid exists in its vapour state over its surface at normal temperature and pressure. This is the result of change of state from liquid to vapour i.e., evaporation. **Evaporation** can be defined as the change of state of liquid to vapour from the surface of liquid at any temperature below its boiling point. Evaporation and boiling both involve the conversion of the same state of matter, but these two phenomena can be differentiated based on the way they take place.

Table 1.3

Evaporation	Boiling
It is a slow process.	It is a fast process.
It takes place from the surface of liquid.	It takes place from the bulk of liquid.
The temperature of the remaining liquid decreases during evaporation.	The temperature of the liquid that is undergoing boiling remains constant.
It can take place at any temperature below the boiling point of liquid.	Every liquid has a fixed boiling point at a particular pressure.

Factors affecting the rate of evaporation

Surface area: The rate of evaporation of a liquid is directly proportional to the surface area of it.

Temperature: With the increase of temperature, the rate of evaporation of a liquid increases.

Humidity: The rate of evaporation of a liquid is inversely proportional to the amount of moisture present in the atmosphere (humidity).

(iii) Condensation

The process which involves the change of matter from gas to liquid on cooling is called **condensation**.

☛ *Examples* Conversion of water vapour or steam to water.

(iv) Solidification

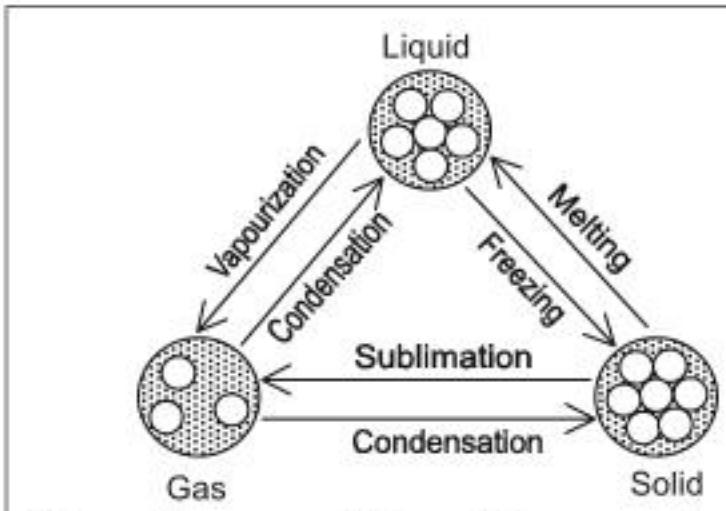
The process involving the change of matter from liquid to solid on cooling is called **solidification or freezing**. The temperature at which freezing occurs at normal atmospheric pressure is called **freezing point** of that liquid.

☛ *Example* Water changes to ice at 0°C under normal atmospheric pressure. Hence 0°C is called the freezing point of water.

Note: Generally, solids expand on melting and liquids contract on freezing.

(v) Sublimation

The process by which some solid substances directly change into the vapour state without passing through the intermediate liquid state is called **sublimation**. The solid obtained on cooling the vapour is called **sublimate** and the vapour formed is called **sublime**.



Schematic representation of interconversion of matter

☛ *Examples* Camphor, iodine etc., get converted to their respective vapour states directly under normal atmospheric pressure.

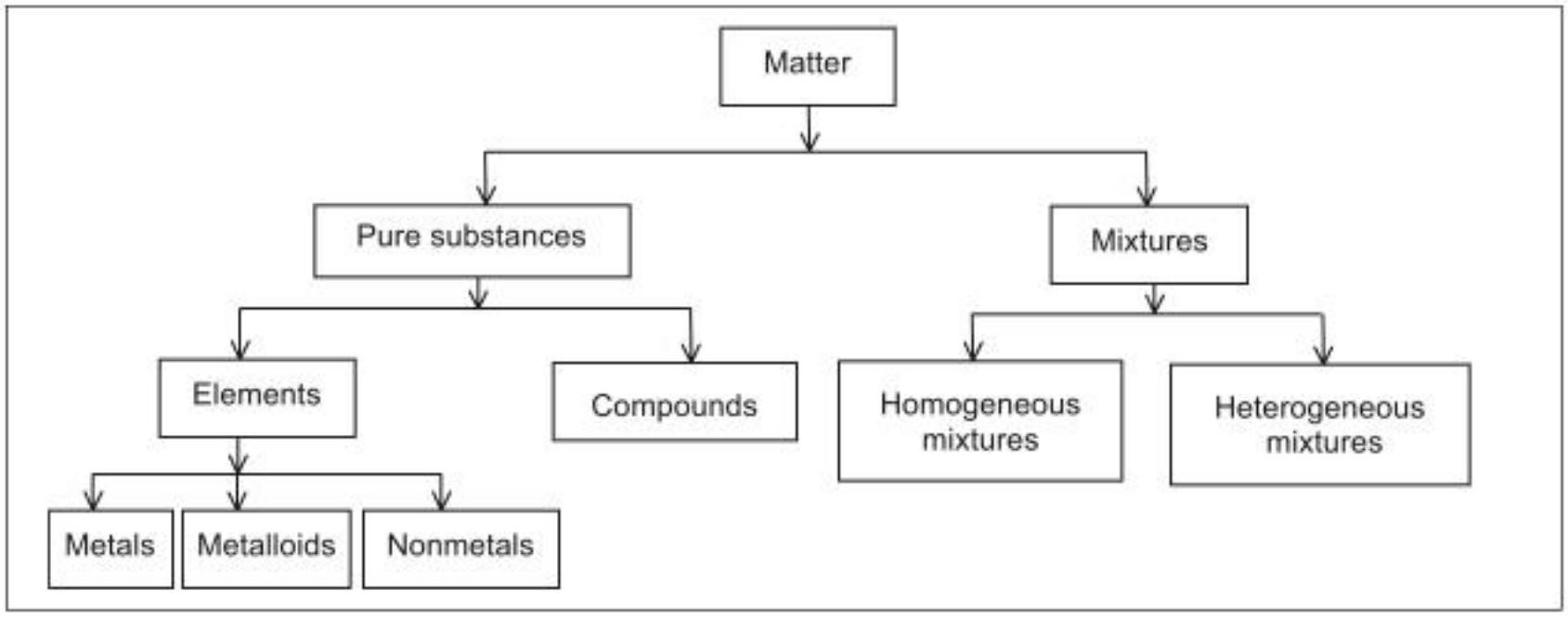
Matter can also be classified based on its composition, in the following way irrespective of the state in which it exists.

If the matter is made up of identical molecules, it is called **pure substance**. The matter which is made up of different types of molecules is called **mixture**. Molecules of matter are made up of still tinier particles called **atoms. Atoms** are the tiniest particles of matter which cannot exist independently. There are very few atoms which exist independently. These are the atoms of helium, neon, argon, krypton and xenon. They remain in the gaseous state in the atmosphere and known as **noble gases**.

Pure substances can further be classified into **elements and compounds** based on the nature of constituent atoms present in their molecule.

If the molecules of a pure substance contain identical atom(s), it is called an **element**. The pure substance in which the molecules are made up of two or more different types of atoms is called **compound**.

Classification of matter based on its composition is schematically represented below



Element

An element is a substance which is constituted of only one kind of atoms and cannot be further divided by any physical or chemical means.

☛ *Examples* Hydrogen, oxygen, chlorine, sodium, potassium etc. are the examples of elements. Molecules of these substances consist of only one type of atoms. Molecules of different elements may contain different number of atoms.

Atomicity of element

The number of atoms that constitute a molecule of an element is called **atomicity** of that element. A molecule of hydrogen is made up of two atoms and hence its atomicity is two. Based on the atomicity, elements can be classified as follows:

(i) **Monoatomic elements:** The elements in which each molecule contains only one atom.

☛ *Example* Cu, Ag, He etc

(ii) **Diatomic elements:** The elements in which each molecule contains two atoms.

☛ *Example* H_2, O_2, N_2 etc

(iii) **Polyatomic elements:** The elements in which each molecule contains more than two atoms.

☛ *Example* O_3, P_4, S_8 etc

An element is made up of identical atoms, but the nature of the atoms are different in different elements which invariably result in difference in their characteristics. Based on the variation in properties, elements are further classified into metals, nonmetals and metalloids.

Comparative study of metals and non-metals

Table 1.4

Property	Metals	Non-metals
State	Solids at room temperature. **Exceptions:** Mercury and gallium are liquids.	Mostly gases. **Exceptions:** Some of the solid nonmetals are carbon, sulphur, phosphorus, iodine whereas bromine is a liquid non-metal.
Melting point and boiling point	Very high melting and boiling point. **Exceptions:** Sodium, potassium, mercury have low melting points and boiling points. Gallium has low melting point but high boiling point.	Low melting and boiling points. **Exceptions:** Carbon, silicon and boron have high melting points and boiling points.
Hardness	Generally hard. **Exceptions:** Sodium and potassium are soft.	Solid non-metals are brittle. **Exception:** Diamond is the hardest naturally occurring substance.
Density	Have high density **Exceptions:** Lithium, sodium and potassium have density lower than water ($1 g/cm^3$)	Have low density **Exception:** *Diamond*
Conductivity	Good conductors of heat and electricity. **Exceptions:** Bismuth and tungsten are poor conductors of electricity.	Bad conductors of heat and electricity. **Exception:** Graphite and gas carbon are good conductors of electricity.
Lustre	Have lustre	No lustre **Exceptions:** Iodine and graphite
Tensile strength	High tensile strength **Exception:** Zinc has very less tensile strength	Do not have tensile strength. **Exception:** Carbon fibre, a recently developed allotrope of carbon.
Malleability and ductility	Generally malleable and ductile. **Exception:** Zinc is neither malleable nor ductile.	Non-malleable and non-ductile **Exception:** Carbon fibres are ductile.
Sonorousness	Sonorous	Non-sonorous
Occurrence	Found in combined state. **Exception:** Only noble metals are found in free state. Silver, gold and platinum are called noble metals.	Found in free state as well as in the combined state.

Metalloids

Metalloids are elements which show the properties of both metals and non-metals.

☛ *Examples* Germanium, arsenic, antimony, selenium and tellurium.

Compounds

A compound is a substance which is formed due to the chemical combination of two or more elements in a definite proportion by mass. The constituents of a compound do not retain their properties and they can be separated only by chemical means.

☛ *Examples* Water, carbon dioxide, hydrochloric acid, sodium chloride, calcium carbonate etc., are a few examples of compounds. A molecule of carbon dioxide is constituted of a carbon atom and two oxygen atoms. Two atoms of hydrogen and one atom of oxygen combine chemically to form a molecule of water.

Mixtures

A mixture is a substance which is formed by mixing two or more substances (elements, compounds or both) physically in any proportion. No chemical reaction takes place during the formation of a mixture and all the constituents of mixture retain their properties. Constituents of mixture can easily be separated by physical means.

☛ *Examples* Solution of sugar and water is a mixture in which sugar and water both retain their properties and can be separated by a simple physical process that is evaporation. Muddy water is another example of mixture of mud and water which can easily be separated by filtration.

Elements and compounds are the substances in which the composition is uniform throughout the matter and hence they are said to be **homogenous**. But the composition of a mixture that is the proportion of its constituents may or may not be uniform throughout. Hence **mixture** may be **homogeneous or heterogeneous**.

Examples of homogeneous and heterogeneous mixtures: A mixture of alcohol and water is an example of homogeneous mixture because the constituents of this mixture is uniformly distributed. A mixture of sulphur and water is an example of heterogeneous mixture because sulphur remains nonuniformly distributed in water.

Some common examples of mixtures are given below:

(1) Milk is a mixture of proteins, fats, vitamins, carbohydrates and mineral salts

(2) Sea water is a mixture of large number of salts and water

(3) Smoke is a mixture of air and carbon particles.

(4) Cooking gas in a mixture of gases like propane and butane

(5) Air is a mixture of nitrogen, oxygen, CO_2 and water vapour

Mixtures of two or more solids are generally heterogeneous while mixtures of two or more gases are always homogeneous. However, a mixture of two or more liquids may be homogeneous or heterogeneous depending on the nature of liquids.

The liquids which completely dissolve in each other are called miscible liquids. They form homogeneous mixtures.

☛ *Example* Water and alcohol.

The liquids which are insoluble in each other, are called immiscible liquids. They form heterogeneous mixtures.

☛ *Example* Coconut oil and water.

Experiment to show the miscibility/immiscibility of two liquids

(i) 30 ml of water is taken in a beaker and 15 ml of alcohol is poured into water. The mixture is stirred well with the help of a glass rod. After few minutes, it is observed that the two liquids dissolve in each other forming a homogeneous mixture. Therefore, the two liquids are miscible liquids.

(ii) 30 ml of water is taken in a beaker and 15 ml of oil is poured into it and the mixture is stirred with the help of a glass rod. After few minutes it is observed that oil forms the upper layer and water forms the lower layer. Hence it can be concluded that water and oil are immiscible liquids and form a heterogeneous mixture.

Comparative study of compound and mixture

Table 1.5

Compound	Mixture
Constituent atoms of elements combine chemically.	Constituent substances are mixed physically.
Constituent elements do not retain their properties in a compound.	The constituents retain their individual properties in a mixture.
Constituents can be separated only by chemical methods.	Constituents can be separated by physical methods.
These are homogeneous.	These can be either homogeneous or heterogeneous.

Separation of mixtures

Unlike elements, compounds are made up of more than one type of elements and mixtures are composed of more than one type of pure substances. The constituent substances of a mixture may be more than one element or compound or both elements and compounds. But the basic difference between compound and mixture is that the constituents of a mixture retain their properties whereas the constituent elements of a compound completely lose their original properties. Hence constituents of mixture can be separated easily by means of some physical processes. There are different methods of separation of mixture based on the physical state and properties of the constituents. Some of the common processes adopted for separation of mixtures are given below:

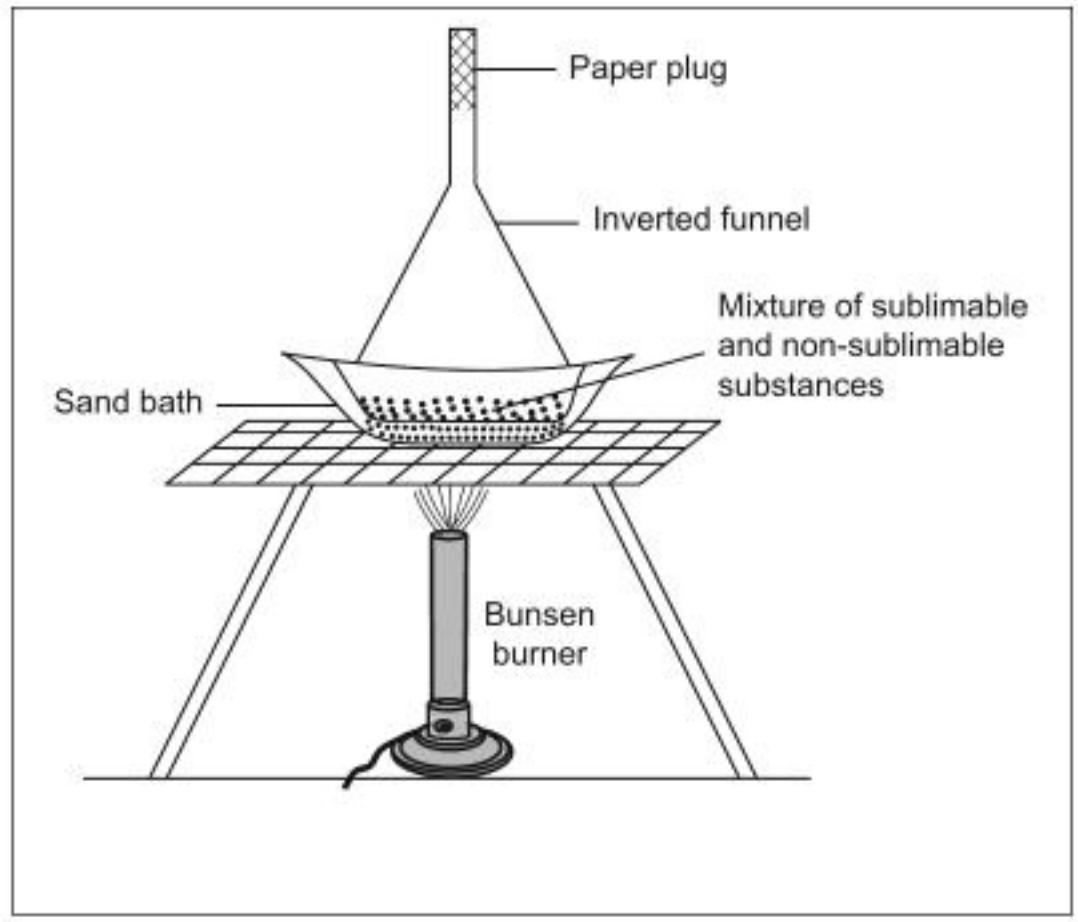
(i) Separation of a mixture constituting two solids

(a) One constituent is a sublimable substance.

☛ *Example* Mixture of common salt and ammonium chloride (sublimable substance). This type of mixture can be separated by a simple physical process called **sublimation process**.

Sublimation

Mixture of sodium chloride and ammonium chloride are taken in a flat basin and a funnel is inverted over it. The outer surface of the funnel is wrapped with a water soaked filter paper and the open end of the stem of the funnel is plugged with a piece of paper or cotton to stop the passage of any vapour. The basin is kept in a sand bath. The sand bath is placed over a wire mesh kept on a tripod stand and then is heated gently with the help of a Bunsen burner.

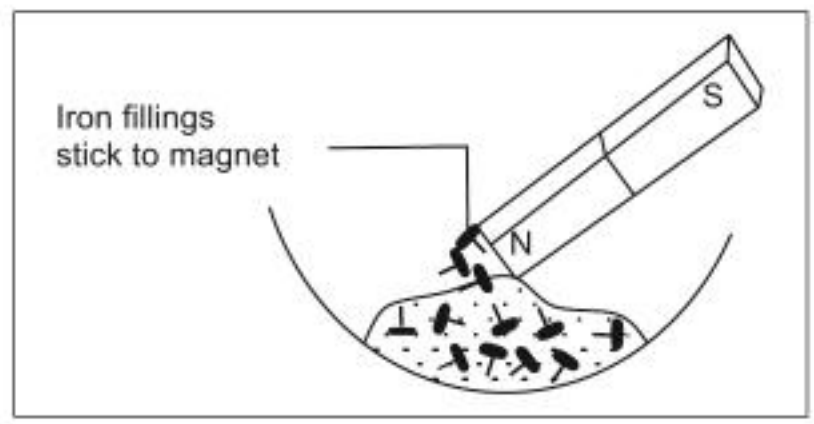


Observation: A white coloured fume is observed which condenses as white powdery substance when it comes in contact with the colder wall of the funnel. The process of heating is continued till the evolution of white vapour is observed.

Conclusion: Since ammonium chloride is a sublimable substance, it sublimes and then condenses as white powder. The substance left over on the basin does not sublime. Hence it is sodium chloride. Ammonium chloride is scrapped off from the wall of the funnel and thus the mixture is separated.

(b) One constituent is a magnetic substance

☛ *Example* Mixture of iron filings and sand can be separated by a simple physical process called magnetic separation as iron is magnetic in nature.



Process: Mixture of iron filings and sand are taken in a flat vessel. A strong bar magnet is brought close to the mixture repeatedly. The iron fillings are attracted by the magnet. The iron fillings cling to the magnet can be shaved off from the surface with the help of piece of cardboard. Thus iron fillings are separated from sand

(ii) Separation of a mixture constituting one solid and one liquid.

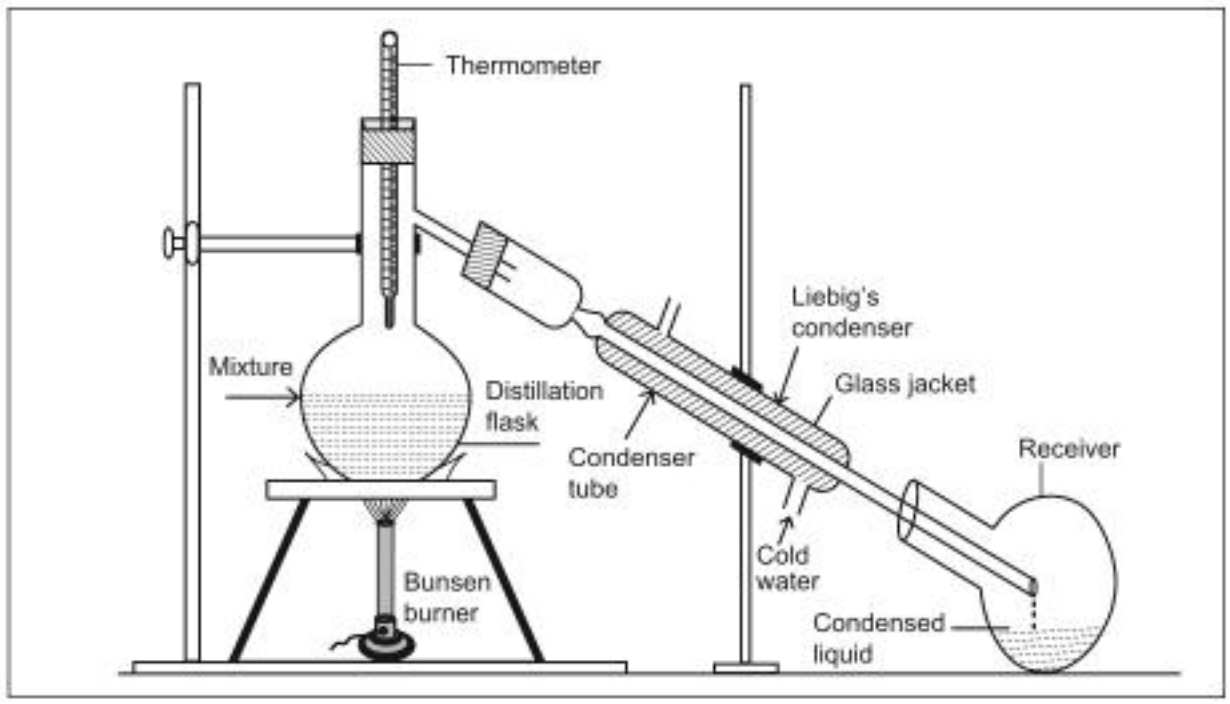
Mixture of solid and liquid can be of different types. The solid may be soluble or insoluble in the liquid. In case of insoluble solid, it may float on the surface of liquid or remain suspended in the liquid or

settle down. Different methods are adopted for the separation of different types of mixture of solid and liquid. The processes are described below:

(a) Separation of a mixture of solid and liquid in which the solid remains in the dissolved state

☛ *Example* Mixture of copper sulphate and water. Copper sulphate is non-volatile (the substance which does not vapourize on heating) and dissolves in water. This type of mixture can be separated by **distillation process.**

Distillation process



Process: The solution of copper sulphate is taken in a round bottomed flask called **distillation flask**. A thermometer and a condenser, known as Liebig's condenser, are attached with the round bottomed flask with the help of adapters. Liebig's condenser is a long glass tube enclosed in a jacket of glass. Cold water is circulated through the glass jacket continuously. The condenser leads to another flask called receiver to collect the liquid that gets separated from the solid during the process of distillation. The distillation flask is placed on a tripod stand and heated with the help of a bunsen burner.

Observation: The solution starts boiling and water vapour obtained is passed through Liebig's condenser where it is converted to water due to condensation and collected in the receiver. Solid residue is observed in the distillation flask.

Conclusion: Water present in the solution is vapourized leaving behind the nonvolatile solid that is copper sulphate in the distillation flask and thus constituents of the copper sulphate solution are separated.

Evaporation is another method of separation of a solid from a solid-liquid mixture. In this method, only the solid can be obtained, but the liquid gets vaporized.

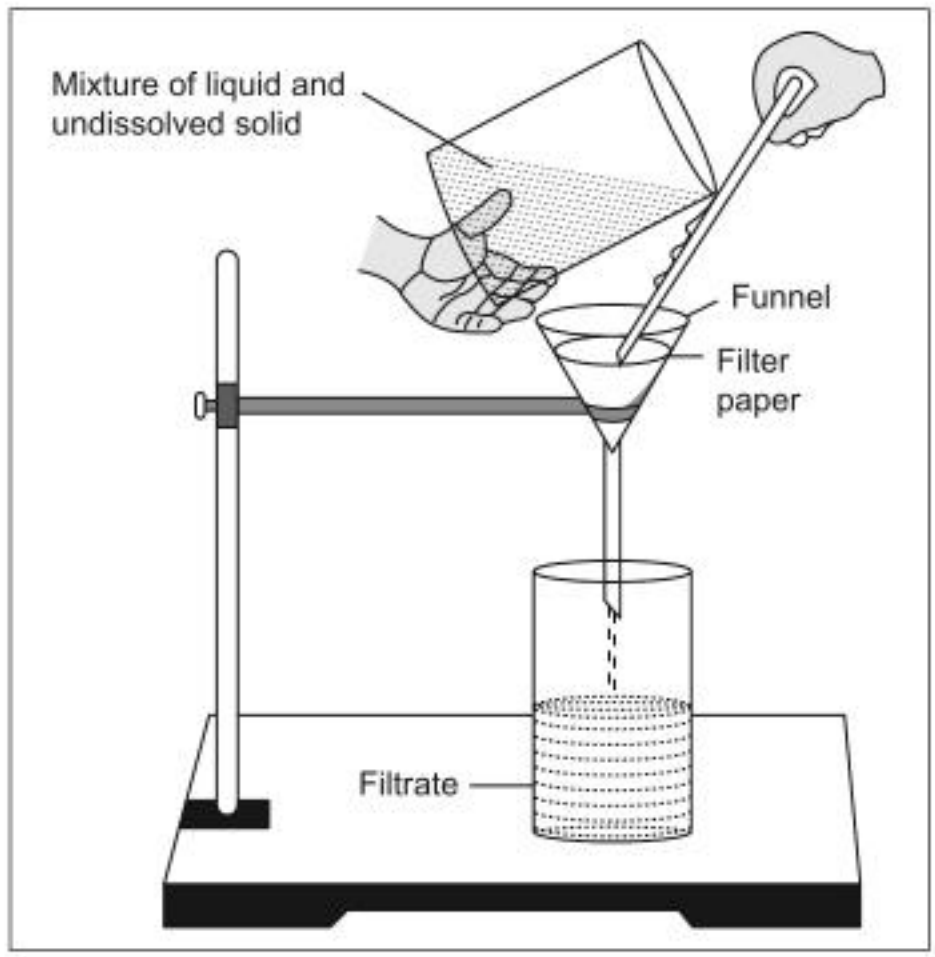
(b) Separation of a mixture of solid and liquid in which the solid does not dissolve.

The insoluble solid may float or remain suspended in the liquid. If the solid particles are heavier, they settle down.

☛ *Example* In a mixture of sawdust and water, sawdust floats on water, fine sulphur particles remain suspended in a mixture of water and sulphur and in a mixture of sand and water, sand particles settle down if the container is kept still for some time. There are two different methods of separation that is filtration and sedimentation followed by decantation for the separation of the above mixtures.

Filtration

All sorts of insoluble solids can be separated from the liquid in this process.



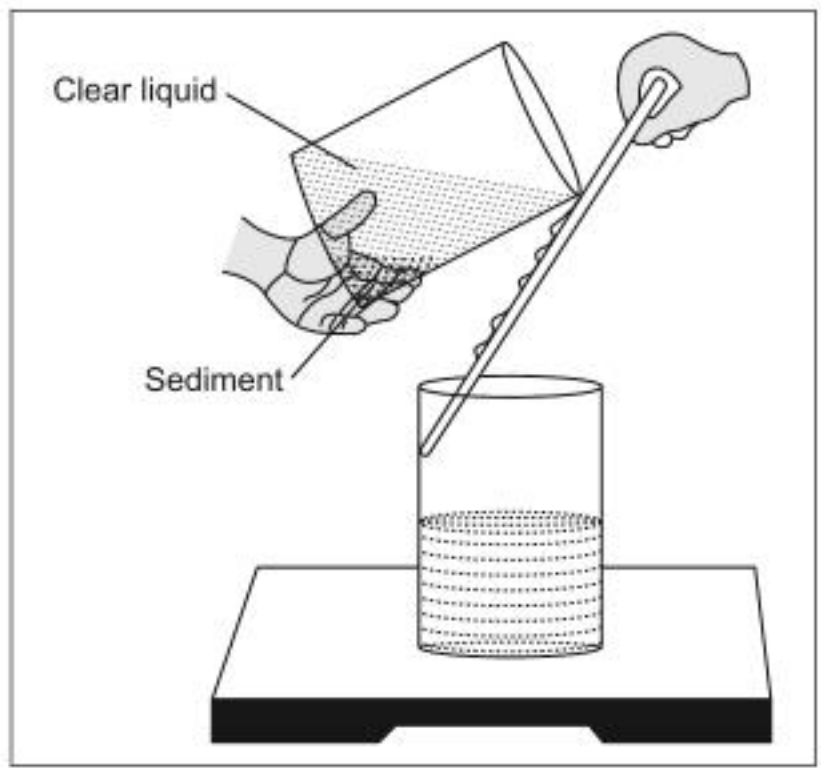
Process: A mixture of saw dust and water is taken in a beaker. A filter paper is folded in the form of a cone and fitted into a funnel by moistening it with a few drops of water. The mixture is poured gently into the filter cone and collected into another beaker.

Observation: The liquid collected is clear and transparent. Sawdust is found over the filter paper.

Conclusion: The mixture of sawdust and water is separated through filtration process. The clear liquid that is collected in the another beaker is called filtrate and solid retained on the filter paper is known as residue.

Sedimentation and decantation

In the mixture of sand and water, the heavier solid particles settles at the bottom and can be separated by this process.



Process: A mixture of sand and water is taken in a beaker and allowed to stand for some time. The heavier sand particles settle down at the bottom. The clear water above it, is gently poured off into another beaker with the help of a glass rod. The glass rod helps to pour off the liquid, without disturbing the solid settled at the bottom.

Observation: The water collected in the second beaker is clear and the sand particles are left behind in the first beaker.

Conclusion: Water is separated from the sand through sedimentation and decantation process.

In the above processes of separation, the mixture taken consists of only two components. In case of mixtures consisting of more than two components, separation of components from the mixture involves more than one method of separation. The methods of separation depend on the nature of constituents in the mixture.

☛ *Example 1*: Separation of the components of a mixture of iron fillings, sand and camphor

Procedure: The mixture of iron filling, sand and camphor spread evenly in basin. A strong bar magnet is brought close to the mixture repeatedly. The iron fillings get attracted by the magnet. The iron fillings cling to the magnet can be shaved off from the surface with the help of piece of cardboard. The remaining constituents are covered with a inverted funnel whose outside surface is wrapped with moist filter paper and the open end of the stem of the funnel is pluged with a piece of paper or cotton to stop the passage of any vapours. Then the mixture is gently heated. Camphor undergoes sublimation and get deposited on the cooler wall of the funnel and later on it is scrapped off. Sand is left behind in the basin. Thus all the constituents of the given mixture are separated by magnetic separation followed by sublimation.

☛ *Example 2*: Separation of the components (potassium nitrate (nitre) + carbon + sulphur) of gunpowder

Procedure: Carbon disulphide is added to a beaker containing gunpowder. Sulphur gets dissolved in carbon disulphide. This mixture is then filtered with the help of a filter paper. The filtrate obtained is taken in a flat vessel and exposed to air till carbon disulphide vapourizes away leaving behind sulphur. The residue obtained contains carbon powder and nitre. It is taken in a beaker containing hot water. Nitre dissolves in hot water. The mixture is then filtered with the help of filter paper. Carbon powder is left on the filter paper as a residue which is collected after drying. The filtrate on evaporation to dryness by heating gives solid nitre. Thus the constituents of gunpowder are separated.

The processes of separation of mixtures discussed above are simple and convenient to carry out, but complete separation of the constituents is not possible through these processes. Despite this, these simple physical processes find widespread applications in different industries and chemical laboratories.

POINTS TO REMEMBER

1. The intermolecular forces of attraction between similar molecules and dissimilar molecules are called cohesive and adhesive forces respectively.
2. Solids, liquids and gases possess characteristic properties based on their molecular arrangements.
3. Matter exists in different states at different ranges of temperature and pressure.
4. Conversion of solid to liquid is called melting and the temperature at which a solid is converted into its liquid state at atmospheric pressure is called the melting point of the solid.
5. Conversion of a liquid to its gaseous state is called vapourization which can be accomplished by two processes namely boiling and evaporation. The first one is a bulk phenomenon and the second one is a surface phenomenon.
6. Rate of evaporation is directly proportional to the surface area of the liquid and temperature and is inversely proportional to humidity.

7. Evaporation causes cooling due to the absorption of heat from the surroundings.
8. Based on the molecular composition, matter is classified into pure substances and mixtures. Pure substances are further classified into elements and compounds.
9. The components of a mixture retain their properties whereas the properties of a compound are totally different from those of its constituent elements.
10. Components of mixtures are separated by different physical methods based on the difference in their physical properties.

test your concepts

Directions for questions 1 to 10: Fill in the blanks.

1. In a _____ properties of the constituents are retained.

2. A mixture of alcohol and water is an example of _____ mixture.

3. A substance which is formed by the chemical combination of two or more elements is called a _____.

4. Boiling point is the temperature at which _____ is converted to _____ at one atmospheric pressure.

5. Non-metals usually exist in _____ state.

6. _____ show the properties of metals and non-metals.

7. With an increase in the surface area of a liquid, the rate of evaporation_____.

8. The conversion of a liquid to its solid state on cooling is called _____.

9. During freezing heat is _____.

10. Atomicity of ozone is _____.

Directions for questions 11 to 30: For each of the questions, four choices have been provided. Select the correct alternative.

11. Generally metals

(1) are solids (2) are good conductors of heat
(3) have high tensile strength (4) All the above

12. A mixture of chalk powder and ammonium chloride can be separated by _____.

(1) distillation (2) evaporation (3) filtration (4) sublimation

13. Identify the soft metal among the following.

(1) Iron (2) Aluminium (3) Magnesium (4) Potassium

14. Which among the following is a bad conductor of electricity?

(1) Zinc (2) Copper (3) Aluminium (4) Phosphorus

15. The smallest particle of an element which may or may not have independent existence is called a/an

(1) atom (2) molecule (3) compound (4) ion

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16. Which among the following is an element?

(1) Calcium oxide (2) Common salt (3) Ozone (4) Water

17. Evaporation is the process of conversion of

(1) a liquid to its gaseous state below the boiling point of the substance

(2) a liquid to its gaseous state at the boiling point of the substance

(3) a solid to its liquid state at the melting point of the substance

(4) a solid to its liquid state below the melting point of the substance

18. The most convenient way of separating saw dust from water is

(1) distillation (2) evaporation

(3) filtration (4) sedimentation and decantation

19. Which among the following statements is true?

(1) Compounds are heterogeneous in nature.

(2) The proportion of constituent elements in a compound is fixed.

(3) The constituent elements retain their properties in a compound.

(4) The formation of compound is a physical process.

20. Which of the following is a heterogeneous mixture?

(1) A mixture of water and sugar

(2) A mixture of water and common salt

(3) A mixture of water and saw dust

(4) A mixture of water and glucose

21. Which among the following is a heterogeneous mixture?

(1) Soda water (2) Liquid ammonia (3) Milk (4) Sugar water

22. Which among the following is a pure substance?

(1) Dilute sulphuric acid (2) Concentrated sulphuiric acid

(3) Aqueous NaCl (4) Molten NaCl

23. Identify true statement among the following.

(1) Gases are highly compressible and diffuse very easily.

(2) Gases are highly compressible and possess strong forces.

(3) Solid molecules are closely packed and highly compressible.

(4) Solid molecules are loosely packed and possess strong forces.

24. Property exploited in the usage of perfumes is_____.

(1) compressibility of gases

(2) diffusion of gases

(3) expansibility of gases

(4) Both (3) and (2)

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25. Baking soda ($NaHCO_3$) is a compound because

(1) the constituents retain their properties.

(2) the constituents can be separated by physical methods.

(3) the constituents are combined chemically.

(4) it is heterogeneous in nature.

26. Which among the following pairs possess low melting points?

(1) Magnesium, mercury

(2) Mercury, manganese

(3) Sodium, potassium

(4) Calcium, manganese

27. A form of which of the following non-metal is the hardest substance?

(1) Phosphorus

(2) Sulphur

(3) Iodine

(4) Carbon

28. Preparation of salt from sea water involves

(1) evaporation

(2) filtration

(3) sedimentation and decantation

(4) sublimation

29. Arrange the following in a proper sequence for the separation of constituents of gun powder

(a) Carbon disulphide is added to the mixture

(b) Carbon powder is separated

(c) Residue is filtered

(d) KNO_3 is separated from its aqueous solution by heating it

(e) Mixture is filtered and hot water is added to the residue

(1) aedbc (2) aecbd (3) abcd (4) None of these

30. The steps involved in the separation of camphor and sand from mixture are given below. Arrange them in a proper sequence.

(a) The wet cloth is put over the funnel and the stem is closed with cotton plug

(b) The mixture of camphor and sand is taken in the china dish and inverted funnel is kept on it.

(c) The vapours are cooled and condensed to form the same solid and sand left behind in the dish

(d) The mixture is heated gently where the vapours of comphor is formed

(1) bcda (2) dabc (3) badc (4) cdbac

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Directions for questions 31 to 33: Match the entries given in column A with the appropriate ones in column B. More than one suitable content of column B can also be considered correct for an entry in column A and some content given in column B may not be the appropriate one for any entry in column A.

31.

Column A				Column B
A.	Distillation	( )	a.	One of the component goes into vapour state on heating
B.	Filtration	( )	b.	Separation of mixture by evaporation and subsequent condensation
C.	Sedimentation	( )	c.	Insoluble solids can be separated from the liquid
D.	Sublimation	( )	d.	Mixture having heavier solid particles are allowed to settle and are separated from clear solution
		( )	e.	Mixture of sand and iodine

32.

Column A				Column B
A.	Atom	( )	a.	Takes the shape of the container
B.	Solid	( )	b.	Smallest particle of the matter
C.	Liquid	( )	c.	Highly compressible
D.	Gas	( )	d.	Any number of free surfaces
E.	Molecule	( )	e.	Rigid
			f.	Basic building block of the matter

33.

Column A				Column B
A.	Boiling	( )	a.	Gas to liquid
B.	Melting	( )	b.	Solid to gas
C.	Condensation	( )	c.	Liquid to solid
D.	Freezing	( )	d.	Liquid to gas
			e.	Solid to liquid

Very short answer type questions

34. Define cohesive and adhesive forces.

35. Define melting and boiling points.

36. Name the factors which affect the rate of evaporation.

37. Define atomicity.

38. What is the difference between element and compound?

39. Give two examples of metals which can exist in liquid state below 35 °C.

40. What is a metalloid? Give two examples.

41. What type of metals are found in free state?

42. Distinguish sublimate from sublime.

43. What is sublimation?

44. What is meant by intermolecular space and intermolecular forces of attraction?

45. Mention the factors on which the existence of matter in a particular state depends.

46. Distinguish between melting and boiling.

47. "All pure substances are homogenous in nature" Justify.

48. How can the constituents of compounds and mixtures be separated respectively?

49. Give two examples for sublimable substances.

50. Name any two metals which are poor conductors of electricity.

51. Mention the difference between filtrate and residue.

52. Name two elements which have atomicity more than three.

53. Name two states of matter which are fluid.

Short answer type questions

54. Distinguish between evaporation and boiling.

55. Classify the elements based on atomicity with examples.

56. Distinguish between compounds and mixtures.

57. Explain the suitable method of separation of ammonium chloride from common salt.

58. Explain the process of sedimentation and decantation.

59. What are homogeneous and heterogeneous mixtures? Give one example for each.

60. Explain classification of matter based on its molecular composition with suitable examples.

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61. Copy and complete the following table.

	Only one free surface	
Solid		
		Spontaneous and rapid diffusion

62. Explain the factors affecting rate of evaporation.

63. Discuss the characteristics of

(a) element

(b) mixture

(c) compound

64. Distinguish between atom and molecule. Give example of elements existing as atoms and molecules.

65. Distinguish between malleability and ductility with an example.

66. What is intermolecular force of attraction? Mention two types of intermolecular force of attraction acting between molecules.

67. What is diffusion? Give one application.

68. Give schematic representation of classification of matter based on its composition.

69. Describe the process of separation of mixture of iron fillings, camphor and sand.

Essay type questions

70. Compare solids, liquids and gases with respect to their physical properties.

71. Compare physical properties of metals and nonmetals

72. Explain the following methods of separation with suitable example

(a) Distillation (b) Filtration

73. Explain different processes of interconversions of states of matter.

74. Describe the process of separation of constituents of gun powder.

75. Give reasons for the following.

(a) Leaves of plants appear to wilt in summer afternoons.

(b) When perfume is sprayed on hand, we feel cool.

(c) Leaves of submerged aquatic plants contain wax coating.

(d) Perspiration is greater in coastal areas than in non coastal areas.

76. Explain sublimation with suitable example.

77. Compare three different states of matter with respect to the arrangement of molecules and their related parameters.

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CONCEPT APPLICATION

Level—1

Directions for questions 1 to 10: State whether the following statements are true or false.

1. Intermolecular space is maximum in gases.
2. Metals are highly ductile but non-malleable.
3. Evaporation is a surface phenomenon.
4. A pure substance is homogeneous in nature.
5. Tellurium shows the properties of both metals and non-metals.
6. Iodine is a lustrous metal.
7. Sodium floats on water.
8. Ammonium chloride is a sublimable substance.
9. The components of compound are separated by physical processes.
10. Sublimation is the process of the conversion of a solid to its liquid state.

Directions for questions 11 to 20: Fill in the blanks.

11. _____ is a surface phenomenon whereas boiling is a _____.
12. _____ state of matter is incompressible.
13. A pure substance is _____ in nature.
14. _____ is a lustrous non-metal.
15. Generally, the components of compound are separated by _____.
16. _____ is the non-metal which is a good conductor of electricity.
17. _____ in humidity increases rate of evaporation.
18. A mixture of two solids is generally _____ while a mixture of any number of gases is _____
19. Mixture of iron fillings and sand can be separated by _____
20. _____ and _____ are the suitable separation methods for mixtures of soluble solids in liquids.

Directions for questions 21 to 41: For each of the questions, four choices have been provided. Select the correct alternative.

21. Identify the wrong statement among the following.
    (1) Molecules of solids possess only vibratory motion.
    (2) Solids are incompressible.
    (3) Solids have only one free surface.
    (4) Gases are highly diffusible.

22. The atomicity of which among the following is the maximum?

(1) Helium (2) Fluorine (3) Ozone (4) Sulphur

23.

Column – A		**Column – B**
(A) Sublimation	( )	(a) NaCl + water
(B) Filtration	( )	(b) Iodine + sand
(C) Evaporation	( )	(c) Sawdust + water

(1) A → a B → c C → b (2) A → c B → a C → b

(3) A → c B → b C → a (4) A → b B → c C → a

24. Which of the following, is a true statement regarding mixtures?

(1) They have variable composition

(2) Mixtures are always homogeneous

(3) Mixtures are always heterogeneous.

(4) None of the above

25. A drop of water contains _____

(1) 2 atoms of hydrogen and one atom of oxygen

(2) 1 molecules of hydrogen and one atom of oxygen

(3) millions of molecules of water

(4) one molecule of hydrogen and one molecule of oxygen

26. Germanium is a _____

(1) gas (2) metal (3) liquid (4) metalloid

27. The process of separation of components of muddy water is

(1) decantation (2) sublimation

(3) magnetic separation (4) None of the above

28. Lime water is a _____

(1) mixture (2) element (3) compound (4) All the above

29. Water sticks to glass due to _____

(1) adhesive forces between water and glass.

(2) cohesive forces between water and glass.

(3) cohesive forces between water molecules.

(4) cohesive forces between glass molecules.

30. The temperature at which solid changes to liquid is called _____

(1) melting point (2) boiling point

(3) evaporation (4) condensation

31. A homogeneous mixture among the following is

(1) milk

(2) muddy water

(3) smoke

(4) air

32. The false statement among the following is

(1) 'every pure substance is homogeneous in nature'.

(2) 'in compounds the constituents do not retain properties'.

(3) 'the constituents of a mixture can be separated by physical method'.

(4) 'during formation of mixtures there is a change in the molecular composition'.

33. Which among the following has strong forces of attraction?

(1) Hydrogen chloride (2) Bromine

(3) Fluorine (4) Chlorine

34. Gases form homogeneous mixture due to their

(1) diffusiblity

(2) high compressibility

(3) expansibility

(4) low density

35. Washing soda (Na_2CO_3) is a compound because the constituents combine

(1) chemically in fixed ratio by weight.

(2) chemically in any ratio by weight.

(3) physically in fixed ratio by weight.

(4) physically in any ratio by weight.

36. Which among the following pairs of substances has strong intermolecular forces of attraction?

(1) Bromine, mercury

(2) Gallium, bromine

(3) Bromine, sodium

(4) Carbon, potassium

37. Among the following which is a pair of soft metals?

(1) Sodium, potassium

(2) Potassium, magnesium

(3) Magnesium, calcium

(4) Calcium, manganese

38. Identify the odd one among the following with respect to tensile strength as well as ductility.

(1) Gas carbon (2) Diamond

(3) Graphite (4) Carbon fibre

39. A mixture contains three components namely glucone-D, water and sand. These three can be collected separately by

(1) filtration and evaporation.
(2) filtration and sublimation.
(3) filtration and distillation.
(4) sedimentation and decantation.

40. Identify a false statement among the following.

(1) Evaporation is a surface phenomenon and causes cooling.
(2) Rate of evaporation is directly proportional to temperature.
(3) Rate of evaporation is inversely proportional to surface area of liquid.
(4) Evaporation causes cooling and depends on humidity.

41. Separation of sawdust from water, can be carried out by the following steps given below. Arrange them in a proper sequence.

(a) The mixture is poured gently in to the filter cone and collected into another beaker which is called filtrate.
(b) A mixture of saw dust and water is taken in a beaker
(c) A filter paper is folded in the form of a cone and fitted into a furnnel by moistening it with few drops of water
(d) Solid retained on the filter paper is called residue.

(1) cabd (2) abcd (3) cdba (4) bcad

Directions for questions 42 to 44: Match the entries given in column A with the appropriate ones in column B. More than one suitable content of column B can also be considered correct for an entry in column A and some content given in column B may not be the appropriate one for any entry in column A.

42.

Column A			Column B	
A.	Sodium	( )	a.	Homogeneous mixture
B.	Sodium chloride	( )	b.	Element
C.	Sulphur in water	( )	c.	Compound
D.	Sugar in water	( )	d.	Heterogeneous mixture
		( )	e.	Impure compound

43.

Column A			Column B	
A.	Boiling	( )	a.	Water changes to ice
B.	Melting	( )	b.	Water vapour changes into water
C.	Condensation	( )	c.	Ice changes into water
D.	Freezing	( )	d.	Water changes into water vapour
		( )	e.	Ice changes into water vapour

44.

Column A			Column B	
A.	Distillation	( )	a.	Mixture of sodium chloride and ammonium chloride
B.	Filtration	( )	b.	Mixture of sodium chloride and water
C.	Sublimation	( )	c.	Mixture of sawdust and water
D.	Sedimentation	( )	d.	Mixture of iron and sulphur
E.	Magnetic separation	( )	e.	Mixture of sand and water

Level—2

Directions for questions 45 to 55: For each of the questions, four choices have been provided. Select the correct alternative.

45. Water shows concave meniscus in a narrow glass tube. This is because

(1) adhesive force is stronger than cohesive force.

(2) adhesive force is weaker than cohesive forces.

(3) cohesive force and adhesive force are equal.

(4) of absence of adhesive force.

46. Iron powder and powder of rust are taken in two containers X and Y respectively. Dilute sulphuric acid is added to both the containers. Then

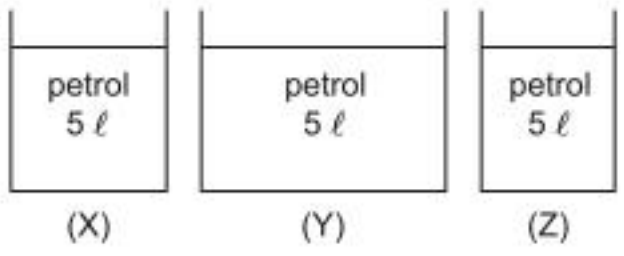
(1) effervescence is observed in two containers.

(2) effervescence is observed in case of X but not Y.

(3) effervescence is observed in case of Y but not X.

(4) no effervescence is observed in both cases.

47.



X, Y and Z containers are placed at 25°C. Then decrease in temperature is more in _____.

(1) X (2) Y (3) Z (4) Cannot be predicted.

48. The inter conversion involved in usage of "odonil" in wash room is_____.

(1) sublimation (2) deposition (3) melting (4) freezing

49. Dogs stretch out their tongues generally in summer because

(1) evaporation leads cooling.

(2) of condensation of water vapour.

(3) of freezing of saliva.

(4) their body temperatures are high.

50. A mixture contains three components namely camphor powder, common salt and water. These can be separated by

(1) filtration and distillation.

(2) filtration, sedimentation and decantation.

(3) sublimation and distillation.

(4) sublimation, sedimentation and decantation.

51. Thermal expansion of solids is the least among the three states of matter due to

(1) high kinetic energy of molecules of solids.

(2) close packing of molecules in solids.

(3) the vibratory motion and rotatory motion of molecules of solids.

(4) the large intermolecular space present in solids.

52. Water shows convex meniscus in narrow ____ and _____ tubes.

(1) glass, plastic

(2) glass, waxcoated glass

(3) wax coated glass, plastic

(4) plastic, coloured glass

53. Among the following a pair of a compound and an element respectively is

(1) iron powder, rust powder.

(2) rust powder, iron powder.

(3) lime, rust powder.

(4) rust powder, lime.

54. Rate of evaporation of water

(1) is more in coastal area than in non coastal area.

(2) is more in non coastal area than in coastal area.

(3) is the same in both coastal and non coastal areas.

(4) cannot be predicted.

55. Sublimation is involved in ____

(1) incense stick and odonil.

(2) camphor and incense stick.

(3) perfume and odonil.

(4) naphthalene balls and camphor.

56. Sodium catches fire easily and chlorine is a harmful gas. But sodium chloride is indispensable in our daily meal. Give reasons.

57. Sand and saw dust are mixed with water. Name the techniques that can separate sand and saw dust from water.

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Fill in the blanks

11. Evaporation, bulk phenomenon
12. Solid
13. homogeneous
14. Iodine
15. chemical methods
16. Graphite
17. Decrease
18. heterogeneous, homogeneous
19. magnetic separation
20. Evaporation, distillation

Multiple choice questions

21. 3
22. 4
23. 4
24. 1
25. 3
26. 4
27. 1
28. 1
29. 1
30. 1
31. 4
32. 4
33. 2
34. 1
35. 1
36. 4
37. 1
38. 4
39. 3
40. 3
41. 4

Match the following

42. A → b
    B → c
    C → d
    D → a
43. A → d
    B → c
    C → b
    D → a
44. A → b
    B → c
    C → a
    D → e
    E → d

Concept Application Level—2

Multiple choice questions

45. 1
46. 2
47. 2
48. 1
49. 1
50. 1
51. 2
52. 3
53. 2
54. 2
55. 4

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41. Noble metals like gold, platinum, silver are found in free state

42. The process by which some solid substances directly change into the vapour state without passing through the intermediate liquid state is called sublimation. The solid obtained on cooling the vapour is called sublimate and the vapour formed is called sublime.

43. The process by which some solid substances directly change into the vapour state without passing through the intermediate liquid state is called **sublimation**.

44. The space between the constituent molecules of matter is called intermolecular space. The attractive forces that exist between the adjacent molecules of matter are called intermolecular forces of attraction.

45. The two factors on which the existence of matter in a particular state depend are temperature and pressure.

46. The process which involves the change in state of matter from solid to liquid by heating is called melting or fusion. The process which involves the conversion of liquid state to the gaseous state from the bulk of the liquid by heating is called boiling.

47. All pure substances contain particles of only one kind having definite set of properties and their composition cannot be altered by any physical means so we can say that all pure substances are homogenous in nature.

48. The constituents of compounds and mixture can be separated by chemical and physical methods respectively.

49. The two examples of sublimable substances are camphor and iodine.

50. Bismuth and tungsten are poor condouctors of electricity.

51. In the filtration process, the clear liquid that is collected in the beaker is know as filtrate and the solid particles retained on the filter paper are known as residue.

52. Phosphorus (P_4) and sulphur (S_8) are the two elements with atomicity more than three.

53. Liquids and gases are fluids.

Short Answer Type Questions

54.

Evaporation	Boiling
It is a slow process.	It is a fast process.
It takes place from the surface of liquid.	It takes place from the bulk of liquid.
The temperature of the remaining liquid decreases during evaporation.	The temperature of the liquid that is undergoing boiling remains constant.
It can take place at any temperature below the boiling point of liquid.	Every liquid has a fixed boiling point at a particular pressure.

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52. In case of wax coated glass and plastic tube, cohesive forces are predominant over adhesive forces and hence water shows convex meniscus in narrow wax coated glass tube and plastic tube. Choice (3)

53. Rust is compound that is hydrated ferric oxide. Iron powder is an element. Choice (2)

54. Rate of evaporation is inversely proportional to humidity. In non-coastal areas humidity is less when compared to coastal areas, and hence rate of evaporation of water is more in a non-coastal area when compared to coastal area. Choice (2)

55. Naphthalene balls and camphor undergo sublimation Choice (4)

56. Sodium chloride is a compound. In compound, the constituents (sodium, chlorine) do not retain their properties and so we can take NaCl in our daily meal.

57. As the density of sand is more than saw dust, it settles down and saw dust floats on water. Sand can be separated by sedimentation and decantation. Saw dust can be separated by filtration.

58. In between water molecules and glass molecules, adhesive forces continually act which are predominant over cohesive forces and hence water droplets are observed on the inner walls of the glass tube X. In case of mercury cohesive forces are more than adhesive forces and hence mercury, droplets are not observed on the inner walls of 'Y'.

59. The force of attraction between similar molecules is called cohesive force and that between dissimilar molecules is called adhesive force. In between water and cotton molecules adhesive forces act which are predominant over cohesive forces. As a result cotton clothes can be easily made more wet than synthetic clothes.

60. In solids, strong intermolecular forces of attractions are present between the molecules due to which they expand less on heating.

61. The process of conversion of solid state to vapour state directly without passing through the intermittent liquid state is called sublimation. Camphor undergoes sublimation at atmospheric pressure. As a result, camphor pellets should be preserved in air tight containers.

62. Cotton has the property of absorbing sweat. When this is exposed to atmosphere sweat undergoes evaporation which causes cooling and hence we feel cool by wearing cotton clothes in summer.

63. Ice present in glass tumbler starts melting by absorbing heat from the air around the glass. As a result, moisture present in the air gets condensed and forms tiny water droplets on the outer walls of the container.

64. Gas particles move with high speeds and the intermolecular spaces in gases are very large. These properties of gases allow a gas to diffuse easily into another. As a result, the smell of perfume which is in vapour state reaches quickly to the other corner of the room.

65. Rate of evaporation depends on surface area of liquids. The more is the surface area of the liquid, the more is the rate of evaporation of the liquid. This is due to increased number of surface molecules. When these surface molecules are exposed to atmosphere, they gain energy and escape into atmosphere. And hence hot milk in the saucer gets cooled.

66. In winters morning temperature is very low. As a result, moisture present in the atmosphere condenses and forms tiny droplets of water. These droplets appear as fog and mist.

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$2Fe(OH)_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2O$

2 – Fe – 2
12 – H – 2
3 – S – 3
18 – O – 13

$2Fe(OH)_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 6H_2O$

2 – Fe – 2
3 – S – 3
12 – H – 12
18 – O – 18

Depending on the way the products are formed from the reactants, the reactions are classified into four different types.

Types of chemical reactions

(i) Chemical combination: The reaction in which two substances, that is, elements, compounds or both combine to form a new compound is called **chemical combination.**
Representation: $X + Y \rightarrow XY$

Type	Example
Element – element (synthesis)	$H_2 + Cl_2 \rightarrow 2HCl$
Element – compound	$2SO_2 + O_2 \rightarrow 2SO_3$
Compound – compound	$CaO + H_2O \rightarrow Ca(OH)_2$

(ii) Chemical decomposition: The reaction in which a compound undergoes decomposition to form more than one substance in the presence of heat or light or electricity is called **chemical decomposition.**
Representation: $AB \rightarrow A + B$

Type	Example
Thermal decomposition (In presence of heat)	$2\ Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$
Photolytic decomposition (In presence of light)	$2HOCl \rightarrow 2HCl + O_2$
Electrolytic decomposition (By passing electricity)	$2H_2O \rightarrow 2H_2 + O_2$

(iii) Chemical displacement: When few pieces of zinc is dipped in green coloured ferrous sulphate solution, the colour disappears after some time and iron is found to be deposited. This phenomenon takes place because zinc is more active metal than iron and hence it displaces iron from ferrous sulphate.
When copper is added to the ferrous sulphate solution, no change is observed. From this observation, it can be concluded that copper is less active metal than iron.

The chemical reaction in which the more reactive element displaces the less reactive element from its compound is called **chemical displacement reaction.**

Representation:

$X + YZ \rightarrow XZ + Y$

X is more reactive element than Y.

$Y + XZ \rightarrow$ No reaction

Y cannot displace X from its compound since it is less reactive than X.

☛ *Example:* $Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$

$Cu + FeSO_4 \rightarrow$ No reaction

Some metals liberate hydrogen gas when they are treated with acids such as HCl and dil H_2SO_4. Such metals are more active than hydrogen since they have the ability to displace hydrogen from acids. The metals which cannot displace hydrogen from acids are considered as less active metals than hydrogen.

Depending on the relative tendency of one metal to displace another metal from its compound, the metals are arranged in a series of decreasing order of reactivity. This is called **metal reactivity series.**

Metal reactivity series

Potassium	K	(Most reactive metal)
Sodium	Na	
Calcium	Ca	
Magnesium	Mg	
Aluminium	Al	
Zinc	Zn	Reactivity decreases
Iron	Fe	
Nickel	Ni	
Tin	Sn	
Lead	Pb	
Hydrogen	H	
Copper	Cu	
Mercury	Hg	
Silver	Ag	
Gold	Au	
Platinum	Pt	(Least reactive metal)

The more reactive metal displaces the less reactive metal from its compound.

(iv) Chemical double decomposition/double displacement: The chemical reaction in which the two reactant (compounds) exchange their respective radicals and two other new compounds are formed is called **double displacement reaction.**

Representation:

$AB + XY \rightarrow AY + XB$

Where B and Y are the negative radicals which are exchanged to give AY and XB.

☛ *Example:* $2KNO_3 + FeSO_4 \rightarrow K_2SO_4 + Fe(NO_3)_2$

In the above reactive K^+ (potassium ion) combines with SO_4^- (sulphate ion) and Fe^{+2} (ferrous ion) combines with NO_3^- (nitrate ion) to form two new compounds, K_2SO_4 and $Fe(NO_3)_2$. During certain double displacement reactions, a solid substance is found to be deposited. The solid deposition is called precipitate and this type of reaction is called **precipitation reaction**.

☛ *Example:* $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl\downarrow$

In the above reaction, during the exchange of radicals, silver chloride is formed which is insoluble in water. Therefore it remains as a solid at the bottom of the container as **precipitate.**

POINTS TO REMEMBER

1. An atom contains a small central positive part known as nucleus.
2. Nucleus contains protons and neutrons which are together called nucleons.
3. Electrons revolve round the nucleus in circular paths called orbits or shells.
4. The orbits are named as K, L, M, N ------- and their energies increase with the increase in distance from the nucleus.
5. The outermost shell of an atom is called valence shell.
6. Metals contain less number of electrons in their valence shells and non metals contain more number of electrons in their valence shells. Therefore they form positive and negative ions respectively.
7. A group of atoms possessing either positive or negative charge is called radical.
8. The formula of a compound should be written in such a way that the positive and negative charges are neutralized.
9. Physical and chemical changes can be distinguished with respect to the change in molecular composition.
10. Element-element combination reactions are called synthesis reactions.
11. Displacement reactions are the reactions which involve displacement of less active element from its compound by the more active element.
12. In a double decomposition reaction, if one of the products formed an insoluble solid, it is called precipitation reaction.

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No.	Positive radicals	Negative radicals	Formula	Name of the compound
1.	Al^{+3}	PO_4^{-3}		
2.	Ca^{+2}	NO_3^{-1}		
3.	NH_4^{+1}	SO_4^{-2}		
4.	Al^{+3}	C^{-4}		

62. Distinguish between atomic number and mass number with an example.

63. Draw the geometrical representation of sulphur.

64. Derive the formulae of the following compounds.

(a) Ammonium nitrate

(b) Ferrous sulphate

65. How do you distinguish metals and non-metals with respect to electronic arrangement?

66. Write the electronic configurations of the following elements.

(a) Magnesium (b) Silicon

(c) Sulphur (d) Argon

67. Explain the formation of sodium chloride.

68. Write the symbols of the following elements.

(a) Cadmium (b) Bismuth

(c) Silicon (d) Argon

69. Explain the observable change taking place during reaction of iron with the aqueous solutions of H_2SO_4 and $CuSO_4$ respectively.

Essay type questions

70. Explain in detail the modern structure of atom.

71. Give the electronic configuration and geometrical representation of the following elements.

(a) Flourine (b) Sodium (c) Chlorine (d) Carbon

72. Classify the chemical reactions into various types depending on the way the products are formed by giving suitable examples.

73. Mention the postulates and limitations of Dalton's atomic theory.

74. Write the steps in balancing a chemical equation with an example.

75. What is valency? Write short note on different types of valencies of cations with examples.

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55. The ratio of number of electrons present in four shells of an element is 1 : 4 : 4 : 1, fourth shell is the valence shell. Then mass of total positive charge present in the atom is _____ times to that of mass of electron

(1) 36,740 (2) 27,555 (3) 18,370 (4) 55,110

56. The difference in the number of electrons between K, L and L, M shells is the same for an atom of element 'X' (M shell is the valence shell) and the difference value is the number of valence electrons in M shell of the other element 'Y'. Give the electronic configurations of their stable ions.

(1) 2, 8, 2 and 2, 8, 6 (2) 2, 8 and 2, 8

(3) 2, 8 and 2, 8, 8 (4) 2, 8, 8 and 2, 8, 8

57. The colour change of $CuSO_4$ solution can be observed when it is made to react with

(1) silver (2) silver chloride solution

(3) zinc (4) gold

58. Identify the ratio of the coefficients of the products CuO, NO_2 and H_2O formed respectively when hydrated copper nitrate is thermally decomposed.

$Cu(NO_3)_2.6H_2O \rightarrow CuO + NO_2 + H_2O + O_2$

(1) 2 : 3 : 1 (2) 1 : 2 : 3 (3) 1 : 1.5 : 1 (4) 3 : 2 : 1

59. Which of the following chemical change is a photolytic decomposition reaction?

(1) Decomposition of HOCl on standing.

(2) Formation of hydrogen chloride from their constituent elements.

(3) Decompostion of limestone.

(4) Both 1 and 2.

60. While explaining modern concept of atom, Jack asked the teacher "why are electrons, assumed to be in continuous motion around the nucleus instead of being stationary"? What could be the explanation given by the teacher?

61. A stable neutral atom 'X' contains two completely filled orbits. Find out its mass number if it consists of 10 neutrons.

62. Mass of total positive charge present in an atom is 7348 times to that of the mass of a negativity charged particle. Find the atomic number of an element. Find out its valency.

63. While coming back from school in the school bus, Bill asked his friend Gill to predict the atoms, X and Y which form a stable dinegative ion and a uninegative ion respectively. They have same number of electrons in the L shell which is the shell inner to the valence shell. Predict the answer given by Gill.

64. Predict the valencies of the elements with atomic numbers 7, 15, 16, 18, 19 and justify. Also give the formulae of hydrides formed by the above elements if any.

65. In an atom, L and M shells have the same number of electrons. N shell has one electron less than K shell. Explain the formation of compound by this element and oxygen atom.

66. Explain the formation of the compound formed by two elements with Z = 20 and Z = 17.

67. An atom of an element has the electrons distributed in four shells. If the electrons present in I and IV shells is in 1 : 1 ratio and, the ratio of electrons in II and III shells is also 1 : 1, predict its valency and justify. Write the formulae of (a) nitride (b) silicate (c) chloride.

68. A negative ion of an atom of element X has 18 electrons and 16 protons. Calculate the number of electrons and protons in its corresponding atom. Also calculate the number of neutrons, if the mass number is 2 units more than double the number of protons.

69. If the formula of metal sulphite of a metal M is MSO_3, give the formulae of its

(a) phosphate (b) hydrogen phosphate (c) chloride

70. In a chemical laboratory, a student broke the thermometer while performing an experiment. Immediately, the mercury which was spilled over was removed by the lab-incharge by sprinkling sulphur on it. The teacher asked the students to predict the type of change/reaction associated with the above process. Explain with appropriate reasons.

71. Asha's mother asked her daughter Asha to boil the milk and after some time, she told Usha, Asha's sister to add little curd in the same luke warm milk. Next day, their father while teaching "Transformation of matter" to his daughters wanted to relate the given activity. So he asked them - "what type of change was involved in the activities performed by you yesterday?" Predict the answer given by them and justify.

72. What is the valency of iron in the products formed

(a) when iron is exposed to humid air for a long time?

(b) when red hot iron is made to react with steam?

73. Give the necessary chemical equations and balance them.

(a) Reaction of red hot iron with steam to give Fe_3O_4.

(b) Burning magnesium ribbon in an atmosphere of nitrogen.

(c) Displacement of copper from the solution of its sulphate by zinc.

74. In a science fair, a student took two test tubes labelled A and B filled with copper sulphate solution, then he put magnesium ribbon in test tube A and silver foil in test tube B. Predict the observation and justify.

Level—3

75. An atom of an element 'X' has three completely filled shells. The ratio of electrons in 1 and 4 shells is 1 : 1. Find the atomic number of 'X'. Also write the formulae of its bicarbonate, chromate and phosphide.

76. A metal(M) and a non-metal(X) form a compound with formula M_4X_3. Predict the electronic arrangements of M and X assuming that M has three occupied shells and X has two occupied shells. Also derive the formulae of (a) sulphate (b) dihydrogen phosphate (c) hydroxide of ion of M.

77. Two metals A and B possess the same number of electrons in L shell and they differ by 1 unit in the number of electrons present in valence shell and number of valence electrons are greater in B than A. The ions formed get the configuration of the nearest inert gases namely argon and neon respectively.

Give the probable electronic configurations of metals corresponding to A and B and give the formulae of their corresponding nitrite, nitrate, sulphite and bisulphite.

78. Number of atoms on either side of a chemical equation is balanced by keeping appropriate coefficients and not by changing the subscripts of the elements in the formulae. Justify.

79. An atom of an element has two shells with electrons. The valence shell has 2n + 1 electrons where n is the number of electrons in the inner shell. This element can form a radical 'X' with hydrogen and two radicals Y and Z with oxygens, Z has more number of oxygen than Y. Identify the element and the radicals. Write the reaction taking place between solutions of two salts, AgZ and XCl. Identify the type of reaction.

key points for selected questions

Test your concepts

Fill in the blanks

1. Ca
2. losing two
3. duplet configuration
4. $2SO_3$
5. - Ous
6. phosphate
7. Na_2SO_3, Na_2SO_4
8. physical, molecular compositon
9. both physical and chemical changes
10. coefficients

Multiple choice questions

11. 3
12. 2
13. 2
14. 3
15. 2
16. 4
17. 1
18. 2
19. 3
20. 2
21. 4
22. 1
23. 2
24. 3
25. 4
26. 2

Match the following

27. A → e
    B → d
    C → a
    D → g
28. A → e
    B → d
    C → a
    D → b
29. A → b
    B → a
    C → d
    D → c

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SOLUTIONS

Test your concepts

Fill in the blanks

1. Ca

Symbol of calcium is Ca.

2. losing two

Electronic arrangement of Mg is 2, 8, 2. By losing two electrons, it attains octet configuration.

3. duplet configuration

Duplet configuration is observed in helium which possesses two electrons in 1st shell.

4. $2SO_3$

$2SO_3$ means 2 molecules of SO_3.

5. - Ous

'-ous' is suffix used to name the salt of the corresponding metal with lower valency.

6. phosphate

$PO^{-3}4$ is called phosphate.

7. Na_2SO_3, Na_2SO_4

Na_2SO_3 and Na_2SO_4 are the formulae of sodium sulphite and sodium sulphate respectively.

8. physical, molecular composition

Most of the physical changes can be reversed since there does not involve change in molecular composition of the substance.

9. both physical and chemical changes

$$NH_4Cl_{(s)} \xrightarrow{\Delta} NH_4Cl_{(g)} \xrightarrow{\Delta} NH_3 + HCl$$

Hence it involves both physical and chemical changes.

10. coefficients

The number of atoms on either side of the chemical equation are balanced by keeping appropriate coefficients.

Multiple choice questions

11. H (Z = 1) electronic configuration = 1; He (Z = 2) electronic configuration = 2 Choice (3)

12. MnO_4^- → the charge of permanganate is –1 which is same as bisulphate ion (HSO_4^-) Choice (2)

13. XCl_3, YCl_4 → the valency of X and Y are 3 and 4. Choice (2)

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38. Electrolytic decompositon is a chemical decomposition in which a single reactant is decomposed into more than one products by the passage of electricity.

☛ *Example:* $2H_2O \rightarrow 2H_2 + O_2$

39. Inert gases have 8 electrons in their valence shell and hence they are stable. Helium, an inert gas has 2 electrons in the 1st shell which is its valence shell. It is stable because 1st shell cannot accommodate more than two electrons.

40. The outermost shell is called valence shell and it can never have more than 8 electrons in any atom.

41. In an atom, the number of electrons is equal to the number of protons inside the nucleus. Since the protons and electrons carry equal and opposite charges, an atom is electrically neutral.

42. A chemical decomposition reaction which takes place in presence of light is called photolytic decomposition reaction.

☛ *Example:* $2HOCl \rightarrow 2HCl + O_2$

43.

Physical change	Chemical change
Boiling of milk, melting of candle	Ripening of fruits, curdling of milk, rusting of iron, blackening of silverware

44. In order to satisfy the law of conservation of mass (atoms can not be created or destroyed), a chemical equation should be balanced.

45. Dissolution of calcium oxide in water is a compound-compound combination reaction.

46. It is called precipitation reaction.

47. It is decomposition reaction.

48. (i) $NH_3 + O_2 \rightarrow NO + H_2O$

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

(ii) $FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$

$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

49.

$CaSiO_3$		H_2SO_3	
Ca^{2+}	SiO_3^{-2}	H^+	SO_3^{-2}
Positive radical	Negative radical	Positive radical	Negative radical

Short Answer Type Questions

50. Characteristic of fundamental particles.

	Symbol	Charge	Mass
Proton	p	$1.6.\times10^{-19}C$	$1.67 \times 10^{-27}Kg$
Electron	e	$-1.6 \times 10^{-19}C$	$9.1 \times10^{-31}Kg$
Neutron	n	Nil	$1.72\times10^{-27}Kg$

51. Metals generally have 1, 2, or 3 valence electrons which can be lost to attain octet configuration and thus they form cations. Non-metals have 4, 5, 6 or 7 valence electrons and can only gain electrons to attain octet configuration and thus they form anions.

52. (a) Neutrons = 31 − 15 = 16
(b) Neutrons = 235 − 92 = 143
(c) Neutrons = 39 − 19 = 20

53. (a) $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$
(b) $Zn + 2HCl \rightarrow ZnCl_2 + H_2 \uparrow$

54. A group of atoms possessing either positive or negative charge by losing or gaining one or more electrons is called a radical. The positively charged radicals are ammonium radical (NH_4^+) and hydronium radical (H_3O^+). All other radicals are negatively charged.

SO_3^{-2}, SO_4^{-2}, CO_3^{-2} are some examples of bivalent negative radicals.

55. The following table gives the comparative study of physical and chemical change.

	Physical change	Chemical change
(i)	Molecular composition of the matter does not change.	Molecular composition of matter changes.
(ii)	No new substance is formed. Only the physical appearance or behaviour changes.	New substance is formed.
(iii)	This change is called temporary or reversible because the previous form of matter can easily be revived.	This change is called permanent or irreversible because the previous form of matter cannot be revived by physical processes.

56.

Type	Example
Element – element (synthesis)	$H_2 + Cl_2 \rightarrow 2HCl$
Element – compound	$2SO_2 + O_2 \rightarrow 2SO_3$
Compound – compound	$CaO + H_2O \rightarrow Ca(OH)_2$

57. The chemical decomposition which takes place in presence of heat is called thermal decomposition.

☛ *Example:* $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$

58. The chemical reaction in which the two reactant (compounds) exchange their respective radicals and two other new compounds are formed is called double decomposition reaction.

☛ *Example:* $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

59. The chemical reaction in which the more reactive element displaces the less reactive element from its compound is called chemical displacement reaction.

$X + YZ \rightarrow XZ + Y$

X is more reactive element than Y.

$Y + XZ \rightarrow$ No reaction

Y cannot displace X from its compound since it is less reactive than X.

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65. Metals generally possess 1 to 3 electrons in their outermost shells and they tend to lose electrons to form positive ions called cations. Nonmetals possess 4 to 7 electrons in their valence shells and they tend to gain electrons to form negative ions called anions.

66. (a) Magnesium (Z = 12) → (2, 8, 2)

(b) Silicon (Z = 14) → (2, 8, 4)

(c) Boron (Z = 5) → (2, 3)

(d) Argon (Z = 18) → (2, 8, 8)

67. Sodium (Z = 11) has electronic configuration of 2, 8, 1. By losing one electron, it forms Na^+ ion which attains the configuration of neon that is 2, 8. Chlorine (Z = 17) has electronic configuration of 2, 8, 7. By gaining one electron it forms Cl^- ion which attains the configuration of argon that is 2, 8, 8. Since Na^+ and Cl^- ion carry opposite charges a strong force of attraction binds the two ions together. Thus, the compound sodium chloride is formed.

68. (a) Cadmium → Cd

(b) Bismuth → Bi

(c) Silicon → Si

(d) Argon → Ar

69. Fe on treatment with H_2SO_4 liberates hydrogen gas.

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2 \uparrow$

The solution turns green due to the formation of $FeSO_4$.

As Fe is more reactive than Cu, it displaces Cu from $CuSO_4$ solution. Hence blue colour of $CuSO_4$ solution disappears.

$Fe + CuSO_4(aq) \rightarrow FeSO_4 + Cu$

Essay Type Questions

70. The modern concept of atom envisages the following arrangement of fundamental particles in an atom.

(i) The protons and neutrons are concentrated in a small region at the centre of an atom. This central part is known as **nucleus**. The protons and neutrons present inside the nucleus are called **nucleons.**

(ii) The size of the nucleus is very small when compared to the size of the atom. That means, there is vast empty space in the atom.

(iii) Electrons revolve round the nucleus in a definite fixed paths which are called **orbits or shells.**

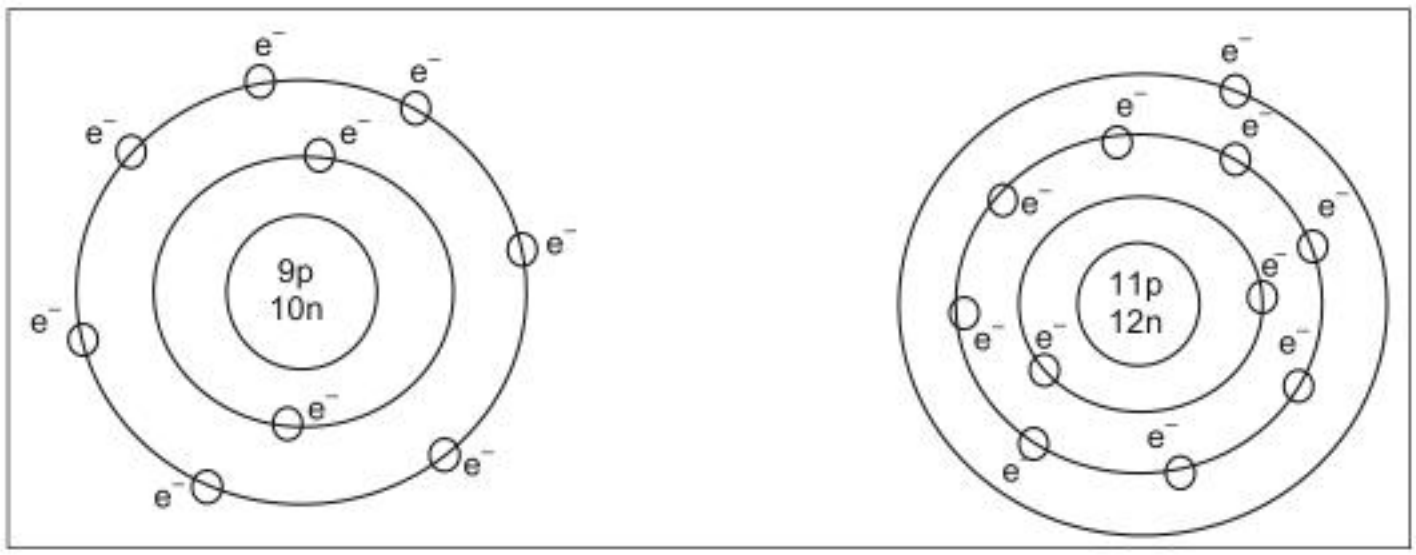
(iv) In an atom, the number of electrons is equal to the number of protons inside the nucleus. Since the protons and electrons carry equal and opposite charges, an atom is electrically neutral.

(v) The various orbits or shells are named as **K, L, M, N**.... or **1, 2, 3, 4**..... and so on. The maximum number of electrons in the various orbits are 2, 8, 18, 32 .... respectively. The energy of the orbit increases with increase in distance from the nucleus.

(vi) The outermost shell is called **valence shell** and it can never have more than 8 electrons in any atom.

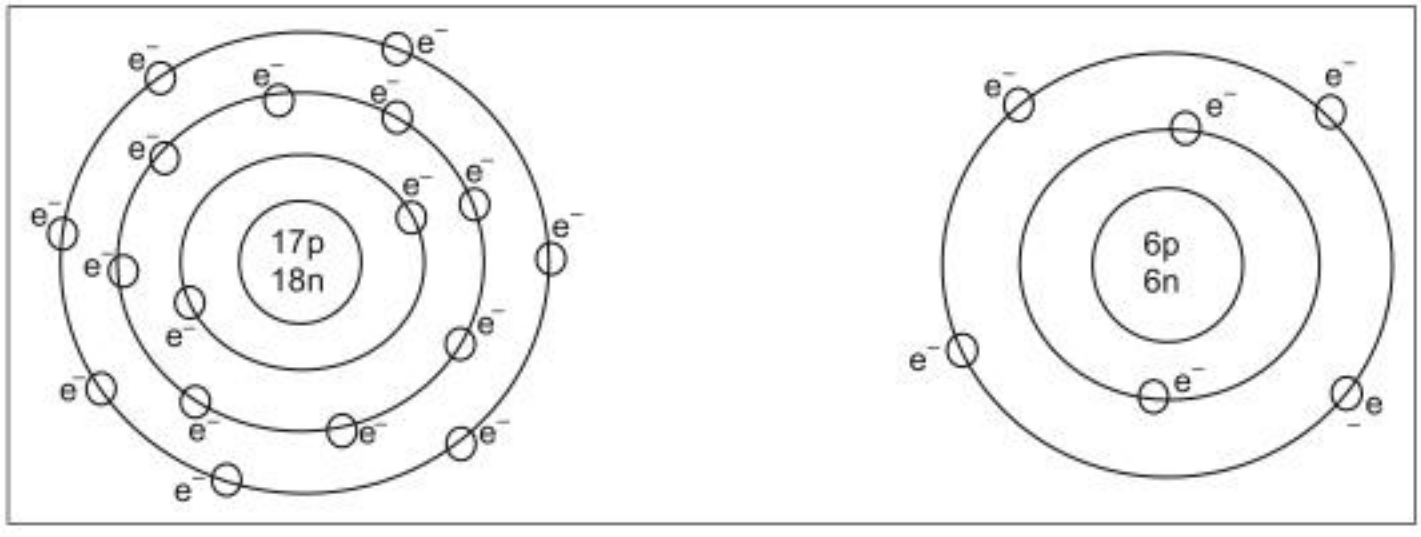
71. (a)
Fluorine Z = 9
Electronic arrangement = 2, 7

(b)
Sodium Z = 11
Electronic arrangement = 2, 8, 1



(c)
Chlorine Z = 17
Electronic arrangement = 2, 8, 7

(d)
Carbon Z = 6
Electronic arrangement = 2, 4



72. Types of chemical reactions

(i) Chemical combination: The reaction in which two substances, that is, elements, compounds or both combine to form a new compound is called chemical combination.

Representation: $X + Y \rightarrow XY$

Type	Example
Element – element (synthesis)	$H_2 + Cl_2 \rightarrow 2HCl$
Element – compound	$2SO_2 + O_2 \rightarrow 2SO_3$
Compound – compound	$CaO + H_2O \rightarrow Ca(OH)_2$

(ii) Chemical decomposition: The reaction in which a compound undergoes decomposition to form more than one substance in the presence of heat or light or electricity is called chemical decomposition.

Representation: $AB \rightarrow A + B$

Type	Example
Thermal decomposition (In presence of heat)	$2\,Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$
Photolytic decomposition (In presence of light)	$2HOCl \rightarrow 2HCl + O_2$
Electrolytic decomposition (By passing electricity)	$2H_2O \rightarrow 2H_2 + O_2$

(iii) Chemical displacement: When few pieces of zinc are dipped in green coloured ferrous sulphate solution, the colour disappears after some time and iron is found to be deposited. This phenomenon takes place because zinc is more active metal than iron and hence it takes away the other constituent that is iron from ferrous sulphate and iron gets separated.

Whereas, when copper is added to the ferrous sulphate solution, no change is observed. From this observation it can be concluded that copper is less active metal than iron.

The chemical reaction in which the more reactive element displaces the less reactive element from its compound is called chemical displacement reaction.

Representation: $X + YZ \rightarrow XZ + Y$

X is more reactive element than Y.

$Y + XZ \rightarrow$ No reaction

Y cannot displace X from its compound since it is less reactive than X.

☛ *Example*: $Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$

$Cu + FeSO_4 \rightarrow$ no reaction

(iv) Chemical double decomposition/double displacement: The chemical reaction in which the two reactant (compounds) exchange their respective radicals and two other new compounds are formed is called double displacement reaction.

Representation: $AB + XY \rightarrow AY + XB$

Where B and Y correspond to the negative radicals which are exchanged to give AY and XB.

☛ *Example*: $2KNO_3 + FeSO_4 \rightarrow K_2SO_4 + Fe(NO_3)_2$

In the above reactive K^+ (potassium ion) combines with SO^{4-} (sulphate ion) and Fe^{+2} (ferrous ion) combines with NO^{3-} (nitrate ion) to form two new compounds, K_2SO_4 and $Fe(NO_3)_2$. During certain double displacement reactions, a solid substance is found to be deposited. The solid deposition is called precipitate and this type of reaction is called precipitation reaction.

☛ *Example*: $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

In the above reaction, during the exchange of radicals, silver chloride is formed which is insoluble in water. Therefore it remains as a solid at the bottom of the container as **precipitate.**

73. The main postulates of Dalton's atomic theory are:

(i) Matter is composed of tiny indivisible particles called **atoms.** They cannot be created or destroyed or transformed into atoms of another element.

(ii) Atoms of a given element are identical in all respects.

(iii) Atoms of different elements are different from each other in all respects.

(iv) Atoms of different elements take part in the chemical reaction and combine in a simple integral ratio to form compounds.

(v) When elements react, the atoms may combine in more than one simple whole number ratio.

Dalton's atomic theory has been contradicted with the advancement of science and modified on the basis of further research and discoveries.

Limitations of Dalton's atomic theory

(i) With the discovery of subatomic particles, that is the electron, proton and neutron, it was concluded that atoms can be further divided.

(ii) Discovery of isotopes proved that atoms of the same element may possess different atomic weights, that is atoms of same elements may not be identical in all respects. For example isotopes of hydrogen namely, protium ($_1H^1$) deuterium ($_1H^2$)

(iii) In some cases, atoms of different elements are found to have same mass number that is atoms of different elements may be identical. For example, calcium and argon are found to have same mass number.

74. Example: $Mg + O_2 \rightarrow MgO$ is an unbalanced chemical equation. This is called skeletal equation. A systematic procedure should be followed for balancing the chemical equation.

Step I The number of times an element occurs on both sides is counted. The element which appears the least number of times should be balanced first.

Step II Among the elements with same frequency of occurences, the metallic element is balanced first followed by nonmetallic element.

Step III Hydrogen and oxygen is balanced at the end.

☛ *Examples:* R P

$Mg + O_2 \rightarrow MgO$

$1 - Mg - 1$

$2 - O - 1$

$Mg + O_2 \rightarrow 2MgO$

$1 - Mg - 2$

$2 - O - 2$

$2Mg + O_2 \rightarrow 2MgO$

75. Valency: The number of electrons gained or lost by an atom of an element for attaining stable octet or duplet configuration is called **valency**.

When an atom loses one or more electrons, the number of protons in it becomes more than the number of electrons and hence the ions formed are left with positive charge. This is called positive valency.

When an atom attains stability by gaining one or more electrons, the number of electrons in it becomes more than the number of protons and hence the ion formed becomes negatively charged. This is called negative valency.

The charge on the ion is corresponding to the number of electrons lost or gained. They may be monovalent, bivalent, trivalent and tetravalent which correspond to the valencies, 1, 2, 3, 4 respectively.

The following table represent the valencies of different elements

Element	Type of ion	Representation of ion	Name of ion
Sodium	Monovalent	Na^{+}	Sodium
Chlorine	Monovalent	Cl^{-}	Chloride
Hydrogen	Monovalent	H^{+}	Hydrogen
Zinc	Bivalent	Zn^{+2}	Zinc
Magnesium	Bivalent	Mg^{+2}	Magnesium
Oxygen	Bivalent	O^{-2}	Oxide
Oxygen	Bivalent	O_2^{-2}	Peroxide
Aluminium	Trivalent	Al^{+3}	Aluminium
Nitrogen	Trivalent	N^{-3}	Nitride

Some metals like iron, copper etc exhibit more than one valencies called variable valency by losing different number of electrons.

Concept Application Level—1

True or false

1. True

The electrons enter III shell after II shell gets completely filled by eight electrons.

2. True

Helium possesses stable duplet configuration with 2 electrons in I shell. Hence its valency is zero.

3. False

$Cr_2O_7^{2-}$ is called dichromate ion.

4. False

Rusting of iron is a chemical change in which iron gets corroded in humid air.

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34. $NH_4Cl(s) \xrightarrow{\Delta} NH_4Cl(g) \xrightarrow{\Delta} NH_3(g) + HCl(g)$

It involves both sublimation (physical change) and chemical decomposition (chemical change)

Choice (2)

35. Formation of rust is a chemical change. When iron is exposed to humid atmosphere it forms hydrated ferric oxide ($Fe_2O_3.xH_2O$). Choice (2)

36. (i) The positive ion that is Zn^{+2} followed by the negative ion that is O^{-2} are written with their charges.

(ii) The valencies of ions formed by zinc and oxygen and are written below without positive and negative sign.

(iii) The valencies of zinc and oxide have common factors and hence they are divided by the highest common factor.

(iv) The magnitude of the valencies of the ions should be interchanged and written as subscripts on right side of the respective ions. Choice (3)

Match the following

37. A → f $4SO_2$ represents four sulphur dioxide molecules.

B → g $2Na^+$ represent two sodium ions.

C → b $3O_2$ represent three molecules of oxygen.

D → c $8Cl_2$ represent 8 molecules of chlorine.

38. A → b Charge on aluminum ion is +3.

B → c Charge on of stannous ion is +2.

C → a Charge on of bisulphate is −1.

D → e Charge on sillicate ion is −2.

39. A → c Lead nitrate is decomposed into PbO, NO_2 and O_2.

B → d Zinc displaces iron from $FeSO_4$.

C → b Mutual exchange of ions takes place when NaCl and $AgNO_3$ react.

D → a Sulphur combines with oxygen to form sulphur dioxide.

Concept Application Level—2

40. Electronic configuration of X is 2, 8, 7

Electronic configuration of Y is 2, 8, 6

∴ Valencies of X and Y are 1 and 2 respectively.

$M^{+2}X^-$ $M^{+2}Y^{-2}$

MX_2 MY Choice (1)

41. 'X' should possess five valence electrons. Since its valency is 3.

Hence, Its corresponding hydride is $X^{-3}H^{+1} \Rightarrow XH_3$ Choice (3)

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63.

	X^{-2}	Y^{-1}
E.C	2, 8, 8	2, 8, 8

Electronic configuration of corresponding neutral atoms, X and Y are as follows:

$X \rightarrow 2, 8, 6$ $Y \rightarrow 2, 8, 7$

Atomic numbers of X and Y are 16 and 17 respectively and hence they are sulphur and chlorine.

64.

Atomic number	Element	Electronic configuration	Valency
7	Nitrogen	2, 5	3
15	Phosphorus	2, 8, 5	3
16	Sulphur	2, 8, 6	2
18	Argon	2, 8, 8	0
19	Potassium	2, 8, 8, 1	1

Since N and P need three more electrons to attain octet, their valencies are 3.

Similarly, the valencies of other elements with atomic number 16, 18, 19 are 2, 0 and 1 respectively.

Except argon, all other elements form hydrides.

Phosphorus – PH_3, Potassium – KH

Nitrogen – NH_3

Sulphur – H_2S

Argon does not from any compound

65. The electronic arrangement of the element could be 2,8,8,1. It corresponds to Z = 19 and the element is potassium. Oxygen (Z = 8) has the electronic arrangement of 2, 6. Potassium loses one electron to form K+ ion, oxygen requires 2 electrons to complete its octet. Therefore it takes 2 electrons from two potassium atoms and forms K_2O.

66.

Element	Atomic number	Electronic configuration
Ca	20	2, 8, 8, 2
Cl	17	2, 8, 7

Ca loses two electrons to attain octet while Cl gains an electron to attain octet.

Hence, the formula of the compound is

$Ca^{+2}\ Cl^{-1}$

$CaCl_2$

67.

K	L,	M	N
2,	8	8	2

Hence the valency of an atom of an element (M) with above electronic configuration is 2 and by losing two electrons it attains octet configuration.

(a) Formula of its nitride is $M^{+2}N^{-3} \rightarrow M_3N_2$

(b) Formula of its silicate is $M^{+2}SiO3^{-2} \rightarrow MSiO_3$

(c) Formula of its chloride is $M^{+2}Cl^{-} \rightarrow MCl_2$

68. 16 protons means that the atomic number of the element (X) is 16. That is the electronic configuration is, 2, 8, 6. It has to gain two electrons to attain octet configuration. Hence, the dinegative ion possesses 18 electrons.

$(X^{-2}) = 16 + 2 = 18.$

A – Z = number of neutrons

Mass number = 2 + 2 (number of protons)

= 2 + 2 (16) = 34

∴∴ Number of neutrons = 34 – 16 = 18

Hence, number of neutrons = 18

69. In MSO_3, the valency of sulphite is 2. Hence the valency of M is also 2.

(a) M^{+2} PO_4^{-3} → $M_3(PO_4)_2$

(b) M^{+2} HPO_4^{-2} → $MHPO_4$

(c) M^{+2} Cl^{-1} (1) → MCl_2

70. When mercury gets spilled on the floor or any surface, it can be collected by sprinkling sulphur powder because Hg reacts with S to form HgS.

$Hg + S \rightarrow HgS$

It is an element-element combination that is synthesis reaction.

71. During boiling of milk, the fat particles being lighter than water rise up when some amount of water vaporises. This layer of fat becomes thick and forms a coating over milk on cooling. Since it involves partial separation of the components of milk, boiling of milk is a physical change. Curdling of milk involves partial conversion of lactose sugar into lactic acid. Since there is change in molecular composition, curdling of milk is a chemical change.

72. (a) When Fe is exposed to humid air for a long period of time, it gets rusted.

Rust : $Fe_2O_3 \times H_2O$

Valency of Fe is '3'

(b) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

steam (ferroso ferric oxide)

(Fe_3O_4 is a mixed oxide that is $FeO + Fe_2O_3$)

(Valency of iron in Fe_3O_4 is 2 as well as 3)

73. (a) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

Steam (Ferroso ferric oxide)

(b) $3Mg + N_2 \rightarrow Mg_3N_2$

(c) $CuSO_4 + Zn \rightarrow ZnSO_4 + Cu$

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Formulae	(i)	$Ca(NO_2)_2$	$Al(NO_2)_3$
	(ii)	$Ca(NO_3)_2$	$Al(NO_3)_3$
	(iii)	$CaSO_3$	$Al_2(SO_3)_3$
	(iv)	$Ca(HSO_3)_2$	$Al(HSO_3)_3$

78. If subscripts are changed, the molecular formulae that is composition of the compound is changed. Hence the number of atoms on either side of a chemical equation is balanced by keeping appropriate coefficients.

79. K shell can have only 2 electrons. That means n = 2 and the number of electrons in L shell is 2n + 1 which is equal to 5. The electronic arrangement that is 2, 5 corresponds to nitrogen. Nitrogen can form NH_4^+ radical(x) with hydrogen. Y is NO_2^- and Z is NO_3^-.

$AgNO_3 + NH_4Cl \rightarrow AgCl\downarrow + NH_4NO_3$

This is a double decomposition reaction where silver chloride being insoluble settles at the bottom. Therefore, this is a precipitation reaction.

3

Acids, Bases and Salts

INTRODUCTION

We are very much familiar with the classification of substances as solids, liquids and gases on the basis of their physical state. Similarly, we are aware of the fact that on the basis of chemical composition, the substances are classified as elements, compounds and mixtures. In this chapter, we would be learning about another important categorisation of some chemical compounds into **acids, bases** and **salts.**

It is a familiar experience that some fruits such as oranges, lemons and grapes and other food materials such as tamarind have sour taste. In Latin language, the term **'acidus'** is used for expressing the sour taste. The term **'acid'** derived from 'acidus' has been given to the substances which are responsible for the sour taste of the above food materials. In the same way, the substances which possess bitter taste like bitter gourd and slippery touch like soaps are called **bases.**

Classification of acids based on the source of origin

Many acids are obtained from the parts of plants and some acids are produced by animals also. These are called **organic acids** due to the fact that their primary source of origin are living systems. They can also be synthesized in laboratory.

Table 3.1

Acid	Source
Acetic acid	Vinegar
Ascorbic acid	Lemons
Citric acid	All citrus fruits
Tartaric acid	Tamarind, grapes
Lactic acid	Curd

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Some important chemical properties of acids

Table 3.7

Reaction	Example
Reaction with metals: Some metals displace hydrogen from the strong acids (HCl, H_2SO_4). These are called **active metals.**	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ $Mg + 2HCl \rightarrow MgCl_2 + H_2$
Reaction with metal oxides: All dilute mineral acids react with metallic oxides to form their respective metallic salts and water.	$ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$ $CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$
Reaction with metal carbonates: This reaction also comes under neutralization but accompanied by the release of CO_2 gas along with the formation of salt and water.	$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + CO_2 + H_2O$

Some important chemical properties of bases

Table 3.8

Reaction	Example
Action of heat	
1. Some hydroxides melt on strong heating. They do not undergo decomposition.	NaOH, KOH
2. Other metal hydroxides undergo decomposition on strong heating.	$Ca(OH)_2 \xrightarrow{\Delta} CaO + H_2O$ $2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$
3. Ammonium hydroxide decomposes rapidly to give ammonia gas and water upon slight heating.	$NH_4OH \xrightarrow{\Delta} NH_3 + H_2O$

Comparative study of properties of acids and bases

Table 3.9

Corrosive action on skin: All acids and some alkalies show corrosive action on skin as they form painful blisters when they come in contact with skin.	H_2SO_4 absorbs water from skin tissues. HNO_3 reacts with skin proteins to form a pulp like mass. NaOH and KOH are called caustic soda and caustic potash respectively due to their causticising action on skin.
Reactions taking place between acids and bases: All acids react with alkalies (metal hydroxides) to form salt and water. The reaction of an acid with a base to form salt and water as the products is called **neutralization**.	$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$ $Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$

Neutralization: The reaction between an acid and a base invariably gives salt and water and is called **neutralization.** In a neutralization reaction, one H^+ ion of acid is neutralized by one OH^- ion of base. When all the H^+ ions in the acidic solution are neutralised by same number of OH^- ions of basic solution, it is called **complete neutralization.** The relative amounts of acid and base required for complete neutralization depends upon the total number of H^+ and OH^- ions produced by the respective acid and base.

Indicators: During the process of neutralization, a point called **neutralization point** is reached when all the H^+ ions of acidic solution are neutralised exactly by the OH^- ions of basic solution. Further addition of base to acid or acid to base adds excess OH^- or H^+ ions which changes the nature of solution from acidic to basic or basic to acidic respectively. In order to identify the neutralization point, during the experiment, certain substances are added which show different colours in acidic and basic solutions. Such substances undergo colour change at the neutralization point which indicates the complete neutralization and hence are called **indicators.** Certain naturally occurring substances can act as indicators as they change colour based on the nature of substance. **Example:** Red cabbage juice

The other indicators used are litmus, methyl orange and phenolphthalein.

Action of indicators on acids and bases

Table 3.10

Name of indicator	Colour in acidic solution	Colour in basic solution
Litmus	Red	Blue
Methyl orange	Pink (orange red)	Yellow
Phenolphthalein	Colourless	Pink
Turmeric	Yellow	Red

Salt: Salt is a substance which contains positive and negative ions or radicals and ionises completely in its aqueous solution. These are formed by neutralization reaction.

☛ *Example*: Acid + Base $\xrightarrow{\text{neutralization}}$ Salt + Water

When the reaction between acids and bases happens in such a way that some of the replaceable hydrogen ions in acid or replaceable hydroxyl ions in the base are left unreplaced, then these reactions are called **partial neutralization reactions.** During this process acidic or basic salts are formed.

Types of salts

(1) Normal salts: When all the H^+ ions furnished by the acid molecule are replaced by the metal ions, the salts formed are called **normal salts**. These salts are formed during complete neutralization.

☛ *Example*: $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

$2H_3PO_4 + 3Ca(OH)_2 \rightarrow Ca_3(PO_4)_2 + 6H_2O$

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(5) Mixed salts: The salts which contain more than one basic or acidic radicals are called **mixed salts.** These salts undergo complete dissociation in aqueous solutions. They give the reactions of all the ions produced in aqueous solutions.

☛ *Example:* (i) Sodium potassium carbonate ($NaKCO_3$) (Na^+, K^+ and CO_3^{-2} radicals)

(ii) Bleaching powder ($CaOCl_2$) (Ca^{++}, OCl^-, Cl^- radicals)

(6) Complex salts: The salt which contains one or more simple ions and one complex ion is called **complex salt.**

A complex ion is made up of group of atoms which does not undergo further dissociation into individual atoms or ions and acts as a complete unit.

These salts undergo dissociation into a complex ion and a simple ion.

☛ *Example:* (i) Potassium ferrocyanide $K_4[Fe(CN)_6]$

$$K_4[Fe(CN)_6] \xrightarrow{\text{dissociation}} \underset{\text{Simple ion}}{4K^+} + \underset{\text{(Complex ion)}}{[Fe(CN)_6]^{4-}}$$

(ii) Sodium argentocyanide $Na[Ag(CN)_2]$

Derivation of names of salts The name of a salt is basically derived from the acid from which it is formed. The salts derived from the hydracids are given names ending with '**ide**' suffix. If the salt contains a hydrogen, then hydrogen is added to the suffix.

Table 3.12

Formula of acid	Formula of base	Salt formed	Name of the salt
HCl	NaOH	NaCl	Sodium chloride
H_2S	NaOH	Na_2S	Sodium sulphide
H_2S	NaOH	NaHS	Sodium hydrogen sulphide

The salts derived from oxy acids are given names depending on the type of oxy acid. The salts of **'ous'** acids are given **'ite'** suffix and the salts of **'ic'** acids are given **'ate'** suffix. If hydrogen is present in the salt, hydrogen or bi is added to the name of the radical that is corresponding suffix.

☛ *Examples*

Table 3.13

Formula of acid	Formula of base	Formula of salt	Name of the salt
H_2SO_3	KOH	K_2SO_3	Potassium sulphite
		$KHSO_3$	Potassium hydrogen sulphite
H_2SO_4	NaOH	Na_2SO_4	Sodium sulphate
		$NaHSO_4$	Sodium hydrogen sulphate

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3. Uses of salts

Table 3.16

Chemical name and formula	Common name	Uses
Sodium chloride, NaCl	Common salt	Food additive Preservative for pickles. Manufacture of chlorine and NaOH Antacid tablets
Sodium bicarbonate, $NaHCO_3$	Baking soda	Leavening agent for cakes. Fire extinguisher Washing clothes
Sodium carbonate, $Na_2CO_3.10\ H_2O$	Washing soda	Manufacture of glass Detergents
Sodium nitrate, $NaNO_3$	Chile salt petre	Manufacture of nitric acid, gun powder, and in fire works Fertiliser
Potassium nitrate, KNO_3	Nitre	Manufacture of gun powder, nitric acid Fire works
Ammonium carbonate, $(NH_4)_2CO_3$	Smelling salt	Relief from common cold
Magnesium sulphate, $MgSO_4.7H_2O$	Epsom salt	Laxative
Ferrous sulphate, $FeSO_4.7H_2O$	Green vitriol	Making of ink, curing of leather
Copper sulphate, $CuSO_4.5H_2O$	Blue vitriol	Fungicide in agriculture, dyeing and printing, electroplating
Calcium sulphate hemihydrate, $CaSO_4.\frac{1}{2}H_2O$	Plaster of Paris	Making of statues, setting of broken bones
$K_2SO_4.Al_2(SO_4)_3.24H_2O$	Potash alum	Purification of water
Ammonium chloride, NH_4Cl	Salammoniac	Used as laboratory reagent
Calcium oxychloride, $CaOCl_2$	Bleaching powder	Bleaching clothes and purification of water
Sodium nitrate, $NaNO_3$	Chile salt petre	As fertilizer, in glass and fire works
Sodium thiosulphate, $Na_2S_2O_3$	Hypo	As an antichlor for removing excess of chlorine from the bleached articles in textile industries
Zinc sulphate, $ZnSO_4.7H_2O$	White vitriol	In medicine as eye lotion and in making lithopone, a paint base

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29. Formula of potassium hydrogen sulphite is

(1) $KHSO_3$ (2) K_2SO_3 (3) K_2SO_4 (4) $KHSO_4$

30. Smelling salt is

(1) sodium chloride (2) calcium carbonate

(3) ammonium chloride (4) ammonium carbonate

31. Dibasic weak mineral acid among the following is

(1) acetic acid (2) sulphuric acid (3) phosphoric acid (4) sulphurous acid

32. If a nonmetal forms only two oxides and one oxide on hydrolysis gives an acid, then the nonmetal could be

(1) sulphur (2) carbon (3) phosphorus (4) nitrogen

33. Antacid pair among the following is

(1) $Mg(OH)_2$, NaOH (2) $Mg(OH)_2$, $Al(OH)_3$

(3) KOH, NaOH (4) $Al(OH)_3$, NaOH

34. Which among the following is/are poor conductors of electricity?

(1) Concentrated and pure H_2SO_4

(2) Concentrated and pure HNO_3

(3) Liquid hydrogen chloride

(4) All the above

35. Hygroscopic substance among the following is

(1) calcium oxide (2) sodium oxide (3) common salt (4) calcium chloride

36. Identify the pair of water soluble bases.

(1) Copper oxide, potassium oxide (2) Copper oxide, calcium oxide

(3) Magnesium oxide, potassium oxide (4) Aluminium oxide, magnesium oxide

37. A metallic element is converted into a compound 'A' after a series of reactions. Compound 'A' turns red litmus blue. 'A' on reaction with another compound B which turns blue litmus red gave a compound 'C' which responded to litmus test like compound 'B'. 'C' on further reaction with 'A' gave a compound 'D' which did not respond to litmus test. Identify the correct sequence of steps for the formation of A, B, C and D.

(a) $NaOH + H_2SO_4 \rightarrow NaHSO_4 + H_2O$

(b) $4Na + O_2 \rightarrow 2Na_2O$

(c) $NaHSO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$

(d) $Na_2O + H_2O \rightarrow 2NaOH$

(1) acbd (2) bcad (3) bdac (4) dbac

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44. (i) Sodium chloride

Acid — HCl, base — NaOH

(ii) Potassium sulphate

Acid — H_2SO_4, base — KOH

(iii) Calcium nitrate

Acid — HNO_3, base — $Ca(OH)_2$

45. (i) Carbonic acid → ate

(ii) Nitrous acid → ite

(iii) Sulphuric acid → ate

(iv) Nitric acid → ate

46. Hypo is sodium thiosulphate and its formula is $Na_2S_2O_3$.

47. In sodium nitrate Na^+ is basic radical and NO_3^- is acidic radical.

48. KOH causes causticising action on skin and therefore it is called caustic potash.

49. (i) $CuSO_4.5H_2O$ (Copper sulphate)

(ii) $FeSO_4.7H_2O$ (Ferrous sulphate)

50. In hydrated salts a fixed number of water molecules get attached to each molecule of the salt and these are known as water of crystallization.

51. Formula of plaster of Paris is $CaSO_4.\frac{1}{2}H_2O$

Short Answer Type Questions

52. The acids which have their origin from plants and animal sources are called organic acids

☛ *Examples:* Acetic acid, citric acid, formic acid etc.

The acids which are synthesized from the minerals obtained from earth's crust are called mineral acids.

☛ *Examples:* H_2SO_4, HCl etc.

53. Sulphuric acid is a dibasic acid.

$S + O_2 \rightarrow SO_2$

$2SO_2 + O_2 \rightarrow 2SO_3$

$SO_3 + H_2O \rightarrow H_2SO_4$

54. Some metals displace hydrogen from strong acids such as HCl, H_2SO_4. These are called active metals.

☛ *Examples:* $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

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